

THE INHERITANCE OF POD PUBESCENCE  
IN THE PEANUT (Arachis hypogaea L.)  
AND ITS RELATION TO YIELD

By

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Abstract of Dissertation Presented to the  
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THE INHERITANCE OF POD PUBESCENCE  
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Pod pubescence in peanuts (Arachis hypogaea L.) contributes to pod dirtiness due to soil particles attached to the fruit surface. Pod dirtiness is an undesirable characteristic of peanuts which are marketed unshelled because it reduces their market value. Pod pubescence may affect drying and susceptibility of peanuts to pod and seed disease organisms. On the other hand, pod pubescence may facilitate absorption of water and nutrients through the pods. Studies were conducted to determine the mode of inheritance of pod pubescence and the relation of pod pubescence to yield.

Crosses were made between peanut lines having tomentose (heavily pubescent) pods and lines having glabrous pods. The tomentose lines included PI 306222 and breeding lines maintained in the Florida Peanut Improvement Project. The glabrous lines included the cultivar 'Georgia 119-20', PI 279956 and breeding lines maintained in the Florida Peanut Improvement Project. In all crosses, the  $F_1$  plants had pubescent pods intermediate between the parental pods. No

differences were found between the reciprocal crosses. At least three genes conditioning pubescence,  $Pu_1$ ,  $Pu_2$ , and  $Pu_3$ , were proposed in the cultivated peanut. In most crosses two genes segregating independently and acting additively conditioned pod pubescence. In one cross, one gene was found to control this character. This gene was shown not to be linked to the genes for white seed coat in PI 306222. In crosses involving PI 279956 (Valencia type) and a tomentose line (Virginia botanical type), the mode of inheritance was not known. Modifier genes may have been involved in all crosses.

Six pubescence lines, four of which were  $F_3$  families apparently homozygous for the pubescence levels, and the two parental lines were tested at two gypsum levels for yield of unshelled peanuts, shelled peanuts and sound mature seed in a factorial experiment. The tomentose lines on the average had higher yield than the glabrous lines. Genetic factors other than those for pod pubescence seemed to play a major role in the determination of yielding ability in peanuts. Gypsum appeared to affect only the yield in sound mature seed. All the lines tested responded to gypsum similarly.



## INTRODUCTION

Cultivars of peanuts (Arachis hypogaea L.) differ in the degree of pubescence on the fruit surface. Soil remains attached to the pubescent pods at harvest and after drying and long periods of storage. Pod pubescence is an undesirable characteristic for peanuts which are marketed unshelled because dirtiness reduces their market value. In addition, with more moist soil attached at harvest, the pubescent peanuts may dry more slowly and be more susceptible to pod and seed disease organisms.

On the other hand, water and nutrients have been shown to be absorbed through the pod and the peg (gynophore). The pod hairs which increase the surface of contact may affect this absorption. With an absorptive function, pod hair in peanuts may affect plant growth, vigor and yield. Root hairs are known to be scanty or absent in the peanut plant.

Much effort in peanut breeding is directed toward developing high yielding cultivars with improved resistance to pod and seed disease organisms. Information on the genetic control and physiological implications of pod pubescence would be advantageous toward attaining these goals. The objectives of this investigation are to determine the mode of inheritance of pod pubescence in peanuts and its relationship to yield.

## REVIEW OF LITERATURE

The pubescence characteristic is commonly utilized by taxonomists in plant classification. Specific names such as barbadense, glabra, hirsutum, hispidum, pilosa, tomentose and villosum are frequently found in "Species Plantarum" (39) published in 1753 and in textbooks of plant taxonomy.

### Inheritance of Pubescence in Species Other than *Arachis hypogaea*

Studies on pubescence have been conducted in many species other than *Arachis hypogaea*.

In *Arabidopsis thaliana* (L.) Heynh., hairiness was found to be dominant to hairlessness and controlled by a single gene (17).

In the marrow-stem kale (*Brassica oleracea* L. var *acephala* D. C.), nonhairy first leaf was shown to be recessive to hairy first leaf and a single gene controlled this character (79). According to Sampson (61) this gene also controlled the hairy margin characteristic of new leaves in the curly kale (*B. oleracea* L. var *sabellica* L.) and the green sprouting broccoli (*B. oleracea* L. var *italica* Plenck.).

In soybean, *Glycine max* (L.) Merrill, several genes have been shown to control pubescence (9, 45, 50, 75, 80, 87, 88, 92). A dominant gene for glabrousness was reported (45) and

confirmed (50). Later a recessive gene for glabrousness was found (75). Crosses were made between the dominant glabrous type and the recessive glabrous type (92). The  $F_1$  plants obtained were glabrous and the data in the  $F_2$  fit a 13:3 ratio better than a 3:1 ratio. A model was proposed (92) in which the dominant glabrous parent was assumed to carry a factor for pubescence  $P_2$  but was inhibited from expressing the pubescent character by a factor  $P_1$ , and the recessive glabrous parent was assumed to carry the recessive factor for pubescence  $p_2$  as well as the recessive inhibiting factor  $p_1$ . The model was confirmed by  $F_3$  data (92). According to this model, it should be possible to isolate by appropriate crosses, a third glabrous type in homozygous condition, namely  $P_1 P_1 p_2 p_2$ . But this glabrous type has never been reported. It appears that the authors who studied the dominant glabrous type in soybean (45, 50) were really studying the effect of an inhibiting factor which prevented the production of hairs on the soybean plant. The genes  $P_1$  and  $P_2$  were recently shown to actually belong to different linkage groups (87, 88). The gene  $p_2$  drastically reduces the normal pubescence, resulting in minute hairs, seldom over 0.1 mm in length and with an elongate apical cell usually hooked or bent. This type was recently described as puberulent (9, 88). Additional types of pubescence in soybean, namely, curly type, sparse type and dense type were also reported recently (9). Hybrids between the curly pubescent type ( $p_c p_c$ ) and normal pubescent type ( $P_c P_c$ ) had normal-appearing pubescence in the

seedling stage but soon developed an intermediate semi-curly appearance which at maturity required close inspection to be distinguished from the curly homozygote (9).  $F_2$  data indicated, and  $F_3$  data confirmed that intermediate inheritance was involved. The gene  $P_d$  for dense pubescence was found to be dominant to  $p_d$  for normal pubescence. The gene for sparse pubescence  $P_s$  was shown to be incompletely dominant to  $p_s$  for normal pubescence.  $P_c$ ,  $P_d$ ,  $P_s$ ,  $P_1$  and  $P_2$  are unlinked (9). For the combination of the dense pubescence and sparse pubescence, it was shown (9) that if, for each locus, numerical values were assigned to the genotypes depending on the density of hairs, additive effects were found.

The inheritance of hairs on the leaves, petioles and stems in cotton (Gossypium) has been intensively studied because of their relationship to insect resistance. Hairs on the petioles and the leaves in American Upland cotton (G. hirsutum), Egyptian cotton (G. barbadense) and G. raimondii were controlled by several genes according to Balls (5) and Saunders (64, 65). Hairiness is incompletely dominant to glabrousness in G. tomentosum, G. barbadense and G. hirsutum (23, 40, 68). On the other hand a dominant gene for hairiness was reported for a pubescent mutant in Egyptian cotton (1). Two basic dominant genes  $H_1$  and  $H_2$  and several modifiers were reported by Knight and his coworkers (31-35) and Saunders (64, 65) in G. barbadense, G. hirsutum, G. arboreum and G. tomentosum. Two dominant genes  $H_1^P$  and  $H_2^A$  were reported in Pakistani cultivars;  $H_1^P$

induced hairiness to a lesser degree than  $H_2^A$ . The two genes in dominant condition produced profusely hairy plants (44). It was not known whether  $H_1^P$  and  $H_2^A$  were identical to  $H_1$  and  $H_2$  reported earlier (31-35, 64, 65). Hairiness on the other hand has been reported to be recessive to glabrousness in crosses between the wild glabrous American species *G. armourianum* and the normal hairy Upland cotton. This glabrous character, designated as  $D_2$  smoothness, is controlled by a single dominant gene  $Sm$  (42). A gene  $E^A$ , probably similar to  $Sm$ , exercised epistatic effect on  $H_2^A$  but not on  $H_1^P$  (44). Ramey (57) found the interactions of pairs of the three genes  $H_1$ ,  $H_2$  and  $Sm$ . In the  $H_1 \times H_2$  cross the  $F_1$  was extremely pubescent and in the  $F_2$  population a ratio of 15 plants with increased pubescence to 1 normal plant was observed. In the  $H_2 \times Sm$  cross the  $F_1$  had increased pubescence in the terminals, mature leaves and stems indicating that  $H_2$  was epistatic to  $Sm$ . In the  $F_2$  generation the segregation fit the dominant epistatic ratio of 12 plants with increased pubescence, to 3 plants with normal terminals and glabrous stems to 1 normal plant. In the  $H_1 \times Sm$  cross the  $F_1$  had increased pubescence in the terminals but the stems were glabrous. The  $F_2$  segregation fit a two-factor ratio of 9 plants with increased terminals and glabrous stems, to 3 plants with normal terminals and glabrous stems, to 3 plants with increased pubescence to 1 normal plant (57). The genes  $H_1$  and  $H_2$  were conclusively proven to have different actions. They are probably not duplicates. If they are duplicates,

their functions have diverged since the trichomes they induce are different.

For cotton seed hairs, long lint was reported to be dominant to short lint (4, 78). Incomplete dominance was shown by McLendon (40). Short lint was associated with pubescent leaf and the two conditions were probably pleiotropic effects of a single gene (68). According to Balls (4) uniform lint distribution was dominant to nonuniform distribution. Cotton seed hair coverage (fuzz) varies from "wooly seed" (fuzzy seed) to "felted seed" (fuzzy tip) to "naked seed." Fuzzy seed was recessive to naked seed and monogenically controlled (78). Fuzzy tip was also recessive to naked seed and monogenically controlled as shown by Carver (14). In the  $F_2$  generation of a cross between a line with naked seed and a line with fuzzy seed, a ratio of 12:3:1 of naked-seeded to fuzzy-tipped to fuzzy-seeded plants was obtained (14). Ware (86) on the other hand found a single gene without dominance controlling the cotton seed hair coverage.

In the Japanese morning glory (Ipomoea Nil Roth), Imai (28) found two genes controlling the pubescence on stems. The gene  $H_s$  inhibits the production of hairs while its recessive allele does not, and the gene  $H_h$  acts as an inhibitor to  $H_s$  making the stems hairy.

In the tomato (Lycopersicon esculentum Mill), a gene suppressed hair development and indirectly affected self-pollinating and fruit setting (60). In the mutant plants, hairs of stems, petioles, pedicels and peduncles were modified in form and reduced in number. Hairs on the corolla tips were



also reduced permitting earlier spreading of the tips. More significantly, the hairs that normally bound the anthers together to form a staminal tube were absent, permitting the anthers to diverge. This reduced the chance of self-pollination and therefore fruit setting was drastically reduced in this predominantly self-pollinated species.

In Matthiola incana R. Br., commonly called stock, the ordinary type is fully hairy and the half-hairy type is intermediate between the fully hairy and the glabrous types (63). Saunders (62) reported two hairiness genes H and K interacting with sap color genes. The hairiness genes expressed only in the presence of the sap color genes. Another factor J when present in combination with K produced a lesser degree of hairiness than HK, K having a diluting effect on J.

In oriental tobacco (Nicotiana tabacum L.) varietal differences in hairiness exist (8, 90). The mode of inheritance for leaf pubescence has not been reported but with selection among the  $F_2$  hybrids it was possible to increase the number of hairs per unit area from 1 to 12 percent over the nonselected plants.

Species and cultivars of rice (Oryza) differ strikingly in the degree of pubescence on the sterile lemma and on the fringing of the leaf sheath (20). Pubescence of the sterile lemma is dominant to glabrousness. Hairy leaf sheath is dominant to glabrous leaf sheath.

In pearl millet, Pennisetum glaucum (L.) R. Br., leaf hairiness and bristling are monogenically controlled (70). A single recessive mutant gene suppressing shoot-trichomes

was recently reported by Powell and Burton (56) for pearl millet which was treated under the name P. typhoides (Burm.) Stapf & Hubb. In the mutant plants, hairs on the blade and sheath, barbs along the leaf margins, short hairs and claws on veins of leaf surface, cilia on ligules, hairs on nodes, wooly hairs below base of panicles, rachilla hairs and scabrous and pennate properties of bristles were suppressed, the plumose stigmas were modified into fork-like stylar branches and the hair tufts at the apex of anthers were absent.

Distinct types of black gram or mung bean (Phaseolus mungo L.) were recognized on the basis of pod pubescence (53). Pubescence was shown to be controlled by a single dominant gene.

In sesame (Sesamum indicum L.), Langham (38) reported a dominant gene controlling the pubescent leaf character. He also reported the inheritance of the number of foliar glands on the leaves, stems, flowers and pods. Dominance of the extreme glandular type was incomplete and the distribution of the  $F_2$  plants indicated quantitative inheritance. One dominant gene was shown to be responsible for the presence of glands on the dorsal leaf surface. This gene also determined whether the plant was bicarpellate or tetracarpellate.

Belling (7) studied the inheritance of hairs on the pods of Florida velvet bean, Lyon bean, China bean and Yokohama bean and compared these hairs with the stinging



bristles of the wild species Stizolobium pruritus Piper. The  $F_1$  pods from crosses between velvet bean and other beans had appressed stinging bristles unlike those of the wild species. Two factors were shown to control pod pubescence. The stinging plants had both factors while the downy plants and the long velvet plants had only one factor and the smooth plants had neither of the factors.

Spillman (73) in 1902 showed that a single dominant gene was responsible for glume pubescence in common wheat (Triticum aestivum L.). This has been confirmed by several authors working with common wheat cultivars and other Triticum species (10, 26, 27, 29, 36, 37, 49, 67, 74, 81-83). This gene has been designated Hg. Howard and Howard (26) reported that in some crosses, instead of obtaining a 3:1 ratio, they observed a 15:1 ratio indicating two genes were involved in the cases they termed "complex felting." On the other hand a glume pubescence gene hg<sub>1</sub>, recessive to hg in the cultivar 'Kahla', and another gene with incomplete dominance conditioning glume pubescence in the cultivar 'Loro', were reported (2). Monosomic analyses showed that the latter gene was located on chromosome XIV on which Hg was also located (2, 12, 82). Although a primary gene is responsible for the presence of glume pubescence in T. dicoccum Schubl., hair length and density were under polygenic control (74).

According to Spillman (73) a single recessive gene is responsible for beardedness (presence of awns) in wheat. Howard and Howard (26, 27) on the other hand, reviewed work

of Biffen, Wilson, Schribaux and von Tschermak and Nilsson-Ehle and reported two incompletely dominant genes for beardedness.

Barbed leaf sheath is dominant to smooth leaf sheath and villous auricle dominant to smooth auricle (91). It is not known whether or not these genes are identical to the gene Hg discussed earlier.

### Pubescence in *Arachis hypogaea*

#### Stem Pubescence

In 1919, Waldron (85) reported that in the young peanut plant, the stems and the lower epidermis of the leaflets bore typically three-celled hairs, a long pointed terminal cell with two tiny flattened basal cells.

Badami (3) in 1928 reported that hairy stem was dominant to less hairy stem and that a single gene was responsible for the character. Patel et al. (52), in crosses between sparsely hairy and hairy cultivars, found the  $F_1$  plants surpassed the hairy parent in pubescence. This may indicate transgressive segregation or epistasis, thus the presence of more than one gene. However, according to Patel et al. (52), the  $F_2$  segregated according to a ratio of 1:2:1 of very hairy to sparsely hairy to slightly hairy plants. This indicated monogenic control of stem pubescence (52).

#### Petiolar Pubescence

Hayes (25) in 1933 reported four gradations of hairiness

on the petiole of the peanut plants. The amount of hair varied according to the cultivars, moisture conditions and maturity. On older petioles, the hairs were deciduous (25). Also according to Hayes (25), most runner cultivars had long and short hairs while most of the bunch cultivars had only long hairs. In crosses between slightly hairy and hairy cultivars, plants having from none to many hairs were obtained. This may indicate that petiolar pubescence was polygenically controlled.

#### Pubescence on the Gynophore and the Pod

In 1895, Pettit (54) reported that the epidermal cells of the gynophore develop long thin-walled, one-celled hairs as the gynophore reaches the soil. These hairs, averaging 0.8 mm in length and 0.002 to 0.02 mm in diameter, are slightly enlarged at the base. According to Smith (71) the aerial portion of the gynophore is occasionally glabrous or in some cultivars clothed with a matted mass of hairs. Bledsoe and Harris (11) reported that the matted pubescence was often seen in association with a marked thickening of the gynophore near the point at which it entered the soil.

Richter (59) in 1899 found the pod hairs multicellular and characteristic of the stem hairs. Multicellular pod hairs were also observed by Smith (71). In 1904, Winton (89) described these hairs as thin-walled "root hairs" arising from the center of many epidermal cells. Waldron (85) stated that no hairs were formed on any parts of the ovary or young

fruit when the latter was one-half to three-quarters full size. In his materials, irregular, often branched one-celled hairs were found in the later stages until the fruit was mature. On the mature fruit surface, branched hairs were not seen as often as in the immature fruit. Winton did not find hairs on the peanuts sold by vendors and assumed that this was due to their previous removal by cleaning or by rubbing against each other.

Peanut cultivars differ in the degree of pod pubescence. Beattie (6) in 1911 characterized the 'Virginia Bunch' cultivar as having "bright and clean pods." In many current cultivars, the pods are free of the pubescent characteristic (47, 48, 77). On the other hand, the cultivars 'Florispán' and 'Florigiant' and some Florida breeding lines have varying degrees of pod pubescence on the pods (77). Carver (15) described 'Florigiant' as having "slightly dirty pods because of a fuzz on the surface." No studies reporting the inheritance of peanut pod pubescence were found in the literature.

#### Relation of Pubescence to Yield

Numerous studies have been conducted to determine the relationship of pubescence and the vigor of the plant and its economic value. For example, Painter (51) reviewed the significance of plant pubescence in insect resistance. Plant pubescence was found to confer resistance to some insects (1, 9, 30, 31, 35, 44, 57, 64, 65, 69, 88) and reduce resistance to other insects (43, 55).

Pubescence in wheat is related to its resistance to diseases such as stem rust, "black chaff" and powdery mildew (12, 91).

Total diffuse light reflectance was shown to be different depending on pubescence in the velvet plant, Gynura aurantiaca DC. (18). Isogenic lines of soybeans different in pubescence were found to have different apparent photosynthesis rates (19). On the other hand, in Verbascum thapsus L., foliar hairs had little effect on radiation absorption (94).

No marked differences in water loss were found from hairy and hairless Verbascum thapsus strains (66). On the other hand, leaves with dense hairs were warmer than hairless leaves due to differences in the thickness of the boundary layer resistant to heat and water loss (94). Soybean leaf hairs were shown to slow wind at a distance of 0.5 mm from the leaf surface. When the hairs were turgid they slightly increased cuticular transpiration, but when they were not turgid, they decreased it (93).

The association of pubescence and plant vigor and productivity has been reported in soybean (45, 50, 69, 75, 84, 92), cotton (1) and tomato (60). On the other hand, glume pubescence had little, if any, influence on plant productivity in wheat and the differences in a few cases were too small to have a major effect on yield at the population level (41).

In the peanut, Richter (59) found that the cell walls of peg and pod hairs were suberized and he concluded that these

hairs were not absorptive. On the other hand, water, calcium and other elements such as lithium, sulfur, nitrogen, phosphorus and cobalt have been shown to be absorbed through the pod and the peg (13, 24, 54, 71). The pod hairs possibly play a role in this absorption (11, 21, 24, 58, 71, 76, 85, 89). Pettit (54) and Smith (71) conducted experiments in which peanut plants were cut off from the root system but were still connected to the ground by numerous gynophores. After two weeks the plants showed some dead branches but the majority of them remained as healthy as the plants with intact roots. For a review on other physiological studies concerning the pod and the peg, the reader is referred to Harris and Bledsoe (24). Recently Carver (16) stated that pod pubescence appeared to be associated with high yield of peanuts per plant. However, he showed no experimental evidence for this association.

## MATERIALS AND METHODS

### Inheritance of Pod Pubescence

#### Parental Lines

A number of peanut lines having heavily pubescent pods (hereafter called tomentose lines) are maintained in the Florida Peanut Improvement Project (Table 1). Three of these lines, UF 458-4-9, UF 458-4-9-2 and UF 458-4-1-9 obtained from a cross made in 1961 between two Florida lines, and designated UFP-1, UFP-2 and UFP-3 respectively, and another tomentose line, a white-seeded selection from PI 306222 that originated in Senegal, and designated UFP-4, were used in these studies. PI 306222 was obtained in 1967 from the United States Department of Agriculture Southern Regional Plant Introduction Station, Experiment, Georgia. The above lines are of the Virginia botanical type. The pods in these lines are covered with a profuse mat of hairs. At harvest the pods are very dirty due to a thick layer of soil attached to them (Fig. 1). The soil particles remain attached after the pods are dried (Fig. 2) and stored for many years. Under the dissecting microscope, the hairs can be seen as a network covering the pod, with soil particles trapped in between (Fig. 3). Scanning electron microscopy shows that the soil particles are often deeply embedded in



TABLE 1

## PARENTAL LINES AND THEIR PHENOTYPES

| Designation    | Parental Line                               | Phenotype |
|----------------|---|-----------|
|                | Pedigree, Cultivar or<br>Plant Introduction |           |
| UFP-1          | UF 458-4-9                                  | Tomentose |
| UFP-2          | UF 458-4-9-2                                | Tomentose |
| UFP-3          | UF 458-4-1-9                                | Tomentose |
| UFP-4          | PI 306222                                   | Tomentose |
| Georgia 119-20 | Georgia 119-20                              | Glabrous  |
| UFG-1          | UF 416-2-8-1                                | Glabrous  |
| UFG-2          | UF 431A-13-1                                | Glabrous  |
| UFG-3          | UF 393-9-5-4-2-1-1-2                        | Glabrous  |
| UFG-4          | PI 279956                                   | Glabrous  |





Figure 1. Tomentose and glabrous lines of peanuts at harvest. UFP-2 (left) and Georgia 119-20 (right).



Figure 2. Dried peanut pods of the parental lines.

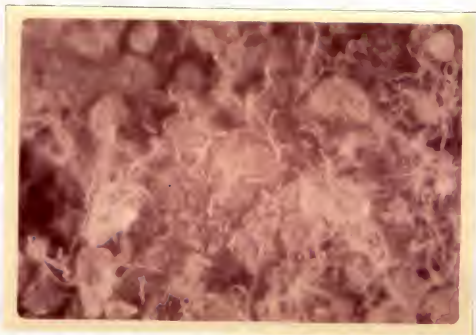


Figure 3. Pod surface in the tomentose line UFP-2 as seen under the dissecting microscope (60x).

the network of collapsed hairs when the pods are dried (Fig. 4).

The glabrous materials (Table 1) include a line derived from the cultivar 'Georgia 119-20' (22), three Florida breeding lines, UF 416-2-8-1, UF 431A-13-1, and UF 393-9-5-4-2-1-1-2, and a line from PI 279956. In these studies the above lines are designated UFG-1, UFG-2, UFG-3, and UFG-4 respectively. The above lines except UFG-4 are of the Virginia botanical type. UFG-4 is derived from a red-seeded Valencia variety which originated in Brazil and was obtained first in 1962 and again in 1971 from the United States Department of Agriculture Southern Regional Plant Introduction Station, Experiment, Georgia. All the glabrous lines have relatively clean pods at harvest (Fig. 1) and are very clean after storage (Fig. 2). Under the dissecting microscope, the pod surface is seen as free or almost free of hairs and dirt (Fig. 5). Scanning electron microscopy often shows a bare ridged surface in the glabrous lines (Fig. 6).

### Crosses

Crossing techniques were similar to the procedure described by Norden and Rodriguez (46). Table 2 shows the crosses that were made between the tomentose lines and the glabrous lines. Crosses, including reciprocal and repeated crosses, were made by Dr. A. J. Norden of the University of Florida Department of Agronomy in 1964, 1966 and 1968. Additional crosses, including reciprocal and repeated crosses



Figure 4. Pod surface in the tomentose line UFP-2 as revealed by the scanning electron microscope (220x).



Figure 5. Pod surface in the glabrous line Georgia 119-20 as seen under the dissecting microscope (60x).

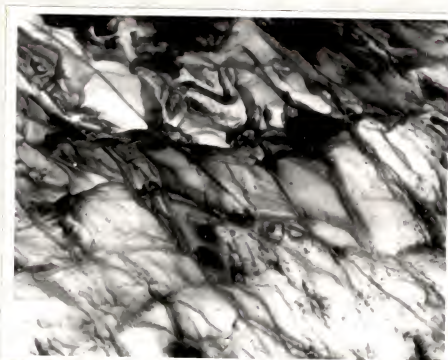


Figure 6. Pod surface in the glabrous line Georgia 119-20 as revealed by the scanning electron microscope (525x).

TABLE 2

GROUPS OF CROSSES<sup>a</sup>, THEIR PARENTAL LINES AND CROSSING YEARS

| Group No. | Glabrous Parent | Cross No. | Parents                | Year Made |
|-----------|-----------------|-----------|------------------------|-----------|
| I         | UFG-1           | 521A      | UFG-1 x UFP-2          | 1966      |
|           |                 | 521B      | Reciprocal             | 1966      |
|           |                 | 8521A     | UFP-3 x UFG-1          | 1968      |
|           |                 | 8521B     | Reciprocal             | 1968      |
|           |                 | 548A      | UFG-1 x UFP-2          | 1971      |
|           |                 | 548B      | Reciprocal             | 1971      |
| II        | UFG-2           | 499A      | UFG-2 x UFP-1          | 1964      |
|           |                 | 499B      | Reciprocal             | 1964      |
|           |                 | 547A      | UFG-2 x UFP-1          | 1971      |
|           |                 | 547B      | Reciprocal             | 1971      |
| III       | Georgia 119-20  | 522A      | UFP-2 x Georgia 119-20 | 1966      |
|           |                 | 522B      | Reciprocal             | 1966      |
|           |                 | 523       | UFP-2 x Georgia 119-20 | 1966      |
|           |                 | 524       | UFP-2 x Georgia 119-20 | 1966      |
|           |                 | 525       | Georgia 119-20 x UFP-3 | 1966      |
|           |                 | 8523A     | Georgia 119-20 x UFP-2 | 1968      |
|           |                 | 8523B     | Reciprocal             | 1968      |
|           |                 | 549A      | UFP-2 x Georgia 119-20 | 1971      |
|           |                 | 549B      | Reciprocal             | 1971      |
|           |                 | 550A      | Georgia 119-20 x UFP-3 | 1971      |
|           |                 | 550B      | Reciprocal             | 1971      |
| IV        | UFG-4           | 500A      | UFP-2 x UFG-4          | 1964      |
|           |                 | 500B      | Reciprocal             | 1964      |
|           |                 | 526       | UFP-2 x UFG-4          | 1966      |
| V         | UFG-3           | 551A      | UFP-4 x UFG-3          | 1971      |
|           |                 | 551B      | Reciprocal             | 1971      |

<sup>a</sup>Crosses grouped according to the glabrous parental lines.

were made by the author in 1971. The crosses were classified into groups according to the pedigrees or sources of the glabrous parents (Table 2).

### Hybrid Generations

Pod tissues are of maternal origin. The fruit resulting from cross-pollination has maternal tissues in the pod and contains the  $F_1$  seed having the hybrid embryos. When the  $F_1$  seed are planted,  $F_1$  plants are obtained, and at harvest the  $F_1$  pods containing the  $F_2$  seed are obtained. The pods therefore are designated one generation behind the seed they contain.

The  $F_1$  seed were space-planted in the field approximately 60 cm apart in rows which were 91 cm wide or planted singly in 15.2-liter glazed pots in greenhouses. Planting occurred during the regular season following the year in which the cross was made except for the crosses made in 1971. The  $F_2$ , and  $F_3$  seed were space-planted in the field approximately 15 or 30 cm apart in rows 91 cm wide. Rows of parental lines were interspaced among the rows of the appropriate  $F_2$  and  $F_3$  plant populations. The plants were harvested when mature either by hand ( $F_1$ ) or by the use of a tractor-mounted digger-shaker-inverter ( $F_2$  and  $F_3$ ). The plants were stacked and the peanuts hand-picked and stored in paper bags until classified.





Figure 7.  $F_2$  segregation; Peanut pods of five ratings and four pubescence classes. Ratings are indicated by numbers. Pubescence classes are: tomentose (To), pubescent (Pu), puberulent (Pl) and glabrous (Gl).

The chemical treatments for the seed, the soil and the plants were in agreement with recommendations of the Florida Agricultural Extension Service for peanut production in the area. The seed were treated with a 1:1 "Captan and Maneb"\* mixture at the rate of approximately 25 g per 100 kg of seed. A few weeks before planting, the field of Arredondo fine sand soil type, received an application of 15.7 kg of N, 27.4 kg of P, 102 kg of K and 22 kg of FTE 503\*\* per hectare. The

\*The use of brand names does not necessarily mean recommendation of these particular brands.

\*\*FTE 503 contained 18.8, 7.5, 7.0, 3.0, 3.0 and 0.2% of Fe, Mn, Zn, Cu, B and Mo, respectively.



field also was treated with the herbicide "Balan" at the rate of approximately  $7 \text{ dm}^3/\text{ha}$ . The systemic insecticide "Disyston" was used at the rate of  $10 \text{ kg}/\text{ha}$  in the row with the seed at planting. "Dinitro" as a pre-emergence herbicide was applied at "cracking," at the rate of approximately  $18.6 \text{ dm}^3/\text{ha}$ . The insecticide "Sevin" and the fungicides "Dithane M-45" and "Benlate" were sprayed as needed to control insects and diseases. In the greenhouses "Dithane M-45" and "Kelthane" were sprayed as needed to reduce the damage from diseases and spider mites. At flowering time, the greenhouses and field plantings received two applications of gypsum at the rate of  $425 \text{ kg}/\text{ha}$  each.

The procedures for the crosses of 1971 were similar to those described earlier except that the  $F_1$  seed were planted in the greenhouses during the winter in 7.6-liter clay pots. Some of the  $F_2$  populations were obtained from planting seed freshly harvested from the greenhouses. Dormancy for these freshly harvested seed was practically broken by germinating them in tape-sealed plastic boxes ( $10 \text{ cm} \times 10 \text{ cm} \times 8 \text{ cm}$ ) containing  $1/6$  of an apple as a source of ethylene gas. After 45 hours, the seed were planted in the field followed immediately by irrigation.

#### Classification of the Segregation Populations

In all crosses, except crosses 499 and 500, the parental and the  $F_1$  shells were saved after the seed they contained were removed for planting. For the crosses other than the

ones made in 1971, the pods of the  $F_1$ ,  $F_2$  and  $F_3$  were compared with those of the parental lines and were scored on the basis of a scale of five classes as follows (Fig. 7):

Score 1: Tomentose pods, like those of the tomentose parental lines described earlier. Pods are very dirty.

Score 3: Very pubescent pods having a thin and discontinuous mat of hairs. Pods are dirty.

Score 5: Pubescent pods having a very thin discontinuous mat of hairs. Pods have dirty patches only.

Score 7: Puberulent pods, fuzzy and covered with short hairs. Pods are moderately clean.

Score 9: Glabrous pods, like those of the glabrous parental lines described earlier. Pods are clean and bright.

For the crosses made in 1971, the  $F_2$  plants were compared with the parental lines and scored in the field after the plants were dug and inverted. The classification was similar to that described earlier. The plants with puberulent pods were more difficult to recognize. They were covered with a very thin layer of dirt that fell off easily upon shaking the plants; then these pods became relatively clean. The  $F_2$  plants in cross 551 were also observed for seed coat color and classified as flesh (pink) or white-seeded.

### $\chi^2$ Analysis of Segregation Data

The first  $F_2$  data collected were fit to genetic ratios

which provided the basis for genetic models and hypotheses on the inheritance of pod pubescence.  $F_3$  data and additional  $F_2$  data from the planting of remnant  $F_2$  seed and new crosses were used for testing the models and hypotheses, using  $\chi^2$  techniques (72). The  $F_2$  data for cross 551 were analyzed to test the relationship between pod pubescence and seed coat color using  $\chi^2$  techniques (72).

#### Relation of Pod Pubescence to Yield

Two parental lines and four selected  $F_3$  families, apparently uniform for pod pubescence or glabrousness, were used in a yield test: The tomentose parental line UFP-2 was designated as L1. The glabrous parental line Georgia 119-20 was designated as L6. The  $F_3$  families were tomentose, tomentose, pubescent and glabrous and designated as L2, L3, L4 and L5 respectively. Two gypsum levels were used:  $G_0$ , no gypsum applied and  $G_1$ , an application of 895 kg/ha.

The six lines and two gypsum levels were arranged in a factorial experiment conducted in a randomized complete block design with four blocks.

The seed were planted 15 cm apart in two-row plots of size 1.8 m x 6 m with rows 91 cm apart. At flowering, gypsum was applied by hand in a 40 cm wide band over the row in appropriate plots. Other chemical treatments were similar to those described earlier. The peanuts were dug 126 days after planting according to the procedures described earlier for the  $F_2$  and  $F_3$  populations. The plots were examined for the degree and uniformity of pod pubescence. After the plants

were sun-cured in the field for two days, the peanuts were removed from the vines by the use of a Benthall stationary carding type picker. The peanuts were forced-air dried at 35° C to a moisture content of 7%. Yield of unshelled peanuts was measured and two samples, 200 g each, of unshelled air-dried peanuts, were graded according to standard United States Department of Agriculture procedures, for the determination of shelling percentage, percentages of sound mature seed, shrivels and damaged seed. Yield of shelled peanuts and sound mature seed per plot were calculated using the grade component means of the two samples. Analyses of variance were conducted and comparisons between treatments were made.

## EXPERIMENTAL RESULTS

### Inheritance of Pod Pubescence

#### Parental Generation

All parental lines bred true for pod pubescence or glabrousness as indicated by the observation on the uniformity of pod pubescence among plants of the parental rows interspaced among the offspring generations during the plantings of 1966, 1968, 1970, 1971 and 1972.

In all crosses, the pods resulting from cross-pollination had the same phenotype with respect to pod pubescence as the selfed pods in the maternal parent. This indicated in effect that pod tissues are of maternal origin.

#### F<sub>1</sub> Generation

The F<sub>1</sub> pods were pubescent in all groups of crosses. The phenotype of the F<sub>1</sub> pods in crosses 499, 500 and 521A were not known, since the empty shells were not saved for observation. However it is likely that they were also pubescent, since the F<sub>1</sub> pods from similar crosses (547, 526 and 548A) had the above phenotype. Therefore it was concluded that the F<sub>1</sub> plants were intermediate between the parents, except in some cases they approached the tomentose parent in pod pubescence. Consistently the F<sub>1</sub> pods in crosses of

groups I, II and IV were more pubescent than those in groups III and V. There were no differences with respect to pod pubescence in  $F_1$  pods of reciprocal crosses.

$F_2$  Generations-Groups I and II Results for 1966, 1968 and 1970

The score classes 3 and 5 were combined (Table 3) in the pubescent class since their ratio was variable which made data heterogeneous. It was assumed that the pubescent genotypes were influenced by environmental effects more than other genotypes or they were influenced by modifier genes. The data in groups I and II indicated a segregation ratio of 5 tomentose to 6 pubescent to 4 puberulent to 1 glabrous plants. The only  $F_1$  seed obtained in cross 521A probably resulted from self-pollination. The number of  $F_2$  plants obtained for this cross and its reciprocal 521B was small making the expectancies for the glabrous class less than 1. Therefore chi-square values were not computed. Two  $F_1$  seed obtained in cross 8521A also resulted from self-pollination as indicated by the  $F_1$  pod characteristics and the nonsegregation of the resulting  $F_2$  families of 42 and 38 plants respectively. The  $F_1$  pods resulting from these two seed had all the characteristics of UFP-3 and lacked the intermediate pod size between their parents and the deep pod reticulation of UFP-3 present in all other  $F_1$  plants. The latter observations were made only after the  $F_2$  nonsegregation was found. A reexamination of all the  $F_1$  shells and pods available was made. No difference in the  $F_2$  data on reciprocal crosses was observed.

TABLE 3

F<sub>2</sub> SEGREGATION IN CROSSES OF GROUPS I AND II  
1966, 1968 AND 1970  
RATIO 5:6:4:1

| Group       | Cross             | No. F <sub>1</sub><br>Plants | No. F <sub>2</sub> Plants <sup>a</sup> |     |     |    | X <sup>2</sup>  | b <sup>b</sup><br>p> |
|-------------|-------------------|------------------------------|--|-----|-----|----|-----------------|----------------------|
|             |                   |                              | To                                     | Pu  | Pl  | G1 | Total           |                      |
| I           | 521A              | 1 <sup>c</sup>               |  |     |     |    |                 |                      |
|             | 521B              | 1                            | 9                                      | 3   |     | 12 | 12 <sup>d</sup> | -                    |
|             | 521 <sup>e</sup>  | 1                            | 9                                      | 3   |     |    | 12 <sup>d</sup> | -                    |
|             |                   |                              |  |     |     |    | 12 <sup>d</sup> | -                    |
|             | 8521A             | 26 <sup>f</sup>              | 237                                    | 306 | 189 | 50 | 782             | 1.020                |
|             | 8521B             | 9                            | 99                                     | 118 | 69  | 21 | 307             | 2.000                |
| Group Total | 8521 <sup>e</sup> | 33                           | 336                                    | 424 | 258 | 71 | 1099            | 1.525                |
|             |                   | 36                           | 345                                    | 427 | 258 | 71 | 1101            | 1.636                |
|             |                   |                              |  |     |     |    |                 | .50                  |
| II          | 499A              | 5                            | 13                                     | 24  | 9   | 2  | 48              | 3.350                |
|             | 499B              | 8                            | 26                                     | 37  | 27  | 6  | 96              | .936                 |
|             | 499 <sup>e</sup>  | 13                           | 39                                     | 61  | 36  | 8  | 144             | 1.819                |
| Group Total |                   |                              |  |     |     |    |                 | .50                  |

<sup>a</sup>To = Tomentose, Pu = Pubescent, Pl = Puberulent, G1 = Glabrous.

<sup>b</sup>Probability of a greater X<sup>2</sup> value.

<sup>c</sup>From a selfed seed.

<sup>d</sup>Expectation too small for X<sup>2</sup> tests.

<sup>e</sup>Sum of reciprocal crosses, excluding selfed seed.

<sup>f</sup>Two were from selfed seed.



Genetic Model for Groups I and II

The intermediate  $F_1$  pods and the  $F_2$  segregation suggested that two loci without dominance, segregating independently and acting additively, were involved. A model for this type of inheritance resulting in the 5:6:4:1 ratio was proposed (Table 4). In this model, the genetic ratio results from

TABLE 4

## GENETIC MODEL FOR CROSSES OF GROUPS I AND II

| Genotype           | Frequency | Combined | Phenotype  |
|--------------------|-----------|----------|------------|
| $Pu_1Pu_1Pu_2Pu_2$ | 1/16      | 5/16     | Tomentose  |
| $Pu_1Pu_1Pu_2pu_2$ | 2/16      |          |            |
| $Pu_1pu_1Pu_2Pu_2$ | 2/16      |          |            |
| $Pu_1pu_1Pu_2pu_2$ | 4/16      | 6/16     | Pubescent  |
| $Pu_1Pu_1pu_2pu_2$ | 1/16      |          |            |
| $pu_1pu_1Pu_2Pu_2$ | 1/16      |          |            |
| $Pu_1pu_1pu_2pu_2$ | 2/16      | 4/16     | Puberulent |
| $pu_1pu_1pu_2pu_2$ | 2/16      |          |            |
| $pu_1pu_1pu_2pu_2$ | 1/16      | 1/16     | Glabrous   |

the combined frequencies in groups of genotypes in a regular two-locus additive model. It is possible that, with a more precise way of scoring, more classes might be distinguished and the segregation might follow more closely the frequencies expected in the second column of Table 4. This model was tested by planting remnant  $F_2$  seed,  $F_2$  seed from new



crosses made in 1971 and  $F_3$  seed in some crosses.

#### $F_2$ Generations-Group III Results for 1966, 1968 and 1970

The data indicated (Table 5) an  $F_2$  segregation ratio of 5:6:5 of tomentose to pubescent to glabrous plants. The absence of the puberulent class was probably due to the short and sparse hairs in this class making it difficult to distinguish from the glabrous class. The results in the reciprocal crosses fit the same ratio.

#### Genetic Model for Group III

The absence of an easily distinguishable puberulent class and the lesser degree of pod pubescence in the  $F_1$  plants in this group suggest that Georgia 119-20 has at least one gene for glabrousness different from those of UFG-1 and UFG-2. A genetic model is proposed for the inheritance of pod pubescence in group III (Table 6). In this model two gene pairs segregating independently and acting additively are involved. However their effects were expressed differently from those in the model for groups I and II (Table 4), resulting in a ratio of 5:6:5 of tomentose to pubescent to glabrous plants. This ratio results from the combination of frequencies in groups of genotypes. The model was tested by additional  $F_2$  and  $F_3$  data.

#### $F_2$ Generations-Group IV Results for 1966 and 1968

The pubescent class was not recovered enough for simple

TABLE 5

F<sub>2</sub> SEGREGATION IN CROSSES OF GROUP III  
1968 AND 1970  
RATIO 5:6:5

| Cross | No. F <sub>1</sub><br>Plants | No. F <sub>2</sub> Plants <sup>a</sup> |     |     | X <sup>2</sup> | p <sup>b</sup> > |
|-------|------------------------------|--|-----|-----|----------------|------------------|
|       |                              | To                                     | Pu  | Gl  |                |                  |
| 522A  | 4                            | 13                                     | 23  | 10  | 46             |                  |
| 522B  | 4                            | 16                                     | 15  | 17  | 48             |                  |
| 522   | 8                            | 29                                     | 38  | 27  | 94             |                  |
| 523   | 9                            | 31                                     | 36  | 26  | 93             |                  |
| 524   | 9                            | 30                                     | 33  | 38  | 101            |                  |
| 525   | 4                            | 16                                     | 19  | 12  | 47             |                  |
| 8523A | 15                           | 158                                    | 175 | 175 | 508            |                  |
| 8523B | 22                           | 237                                    | 269 | 259 | 765            |                  |
| 8523  | 37                           | 395                                    | 444 | 434 | 1273           |                  |
| Total | 67                           | 501                                    | 570 | 537 | 1608           |                  |

<sup>a</sup>To = Tomentose, Pu = Pubescent, Gl = Glabrous.

<sup>b</sup>Probability of a greater X<sup>2</sup> value.

TABLE 6

## GENETIC MODEL FOR CROSSES OF GROUP III

| Genotype  | Frequency | Combined | Phenotype |
|---|-----------|----------|-----------|
| Pu <sub>1</sub> Pu <sub>1</sub> Pu <sub>3</sub> Pu <sub>3</sub> | 1/16      | 5/16     | Tomentose |
| Pu <sub>1</sub> Pu <sub>1</sub> Pu <sub>3</sub> pu <sub>3</sub> | 2/16      |          |           |
| Pu <sub>1</sub> pu <sub>1</sub> Pu <sub>3</sub> Pu <sub>3</sub> | 2/16      |          |           |
| Pu <sub>1</sub> pu <sub>1</sub> Pu <sub>3</sub> pu <sub>3</sub> | 4/16      | 6/16     | Pubescent |
| Pu <sub>1</sub> Pu <sub>1</sub> pu <sub>3</sub> pu <sub>3</sub> | 1/16      |          |           |
| pu <sub>1</sub> pu <sub>1</sub> Pu <sub>3</sub> Pu <sub>3</sub> | 1/16      |          |           |
| Pu <sub>1</sub> pu <sub>1</sub> pu <sub>3</sub> pu <sub>3</sub> | 2/16      | 5/16     | Glabrous  |
| pu <sub>1</sub> pu <sub>1</sub> Pu <sub>3</sub> pu <sub>3</sub> | 2/16      |          |           |
| pu <sub>1</sub> pu <sub>1</sub> pu <sub>3</sub> pu <sub>3</sub> | 1/16      |          |           |

additive models (Table 7). Therefore the data of group IV crosses were not fit to genetic ratios.

TABLE 7

F<sub>2</sub> SEGREGATION IN CROSSES OF GROUP IV  
1966 AND 1968

| Cross | No. F <sub>1</sub><br>Plants | No. F <sub>2</sub> Plants |           |            |          | Total |
|-------|------------------------------|---------------------------|-----------|------------|----------|-------|
|       |                              | Tomentose                 | Pubescent | Puberulent | Glabrous |       |
| 500A  | 8                            | 3                         | 12        | 19         | 62       | 96    |
| 500B  | 8                            | 5                         | 12        | 21         | 58       | 96    |
| 500   | 16                           | 8                         | 24        | 30         | 120      | 192   |
| 526   | 4 <sup>a</sup>               | 2                         |           | 13         | 15       | 30    |
| Total | 20                           | 10                        | 24        | 43         | 135      | 222   |

<sup>a</sup>Only 3 F<sub>2</sub> families obtained.

### F<sub>3</sub> Generation

The F<sub>3</sub> results indicated (Table 8) that the genetic ratios and models proposed above are correct. The F<sub>3</sub> data showed that: (1) In all crosses, some tomentose F<sub>2</sub> plants bred true and some did not. The heterozygous tomentose plants segregated according to the ratio of 3:1 of tomentose to pubescent plants. (2) In all crosses some pubescent F<sub>2</sub> plants bred true while others segregated according to the appropriate ratio for the group (5:6:4:1 or 5:6:5). (3) All puberulent F<sub>2</sub> plants were heterozygous and segregated according to the ratio of 1:2:1 of pubescent to puberulent to glabrous plants. (4) In crosses of groups I and II, the glabrous F<sub>2</sub> plants bred true, and (5) in crosses of group III some glabrous F<sub>2</sub> plants bred true while some others produced F<sub>3</sub> offsprings according to the ratio of 1:3 of pubescent to glabrous plants.

The uniformity in pod pubescence and the prostrate property of all the F<sub>3</sub> families in cross 521A indicated that the only seed obtained during the crossing season of 1966 was likely the result of self-pollination as assumed earlier.

Several F<sub>3</sub> families and plants were lost or discarded during the harvest season due to damage caused by mixing and breaking by the digging equipment.

F<sub>3</sub> data in crosses of group IV indicated segregation for tomentose plants among the offspring of puberulent and glabrous F<sub>2</sub> plants and the true breeding of the tomentose F<sub>2</sub> plants. The plants classified as glabrous in the F<sub>2</sub> may have

TABLE 8

F<sub>3</sub> SEGREGATION  
1971

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |           |                |        |       | Expected<br>Ratio | X <sup>2</sup> | b<br>p > |
|---------------------------------------|---|--|-----------|----------------|--------|-------|-------------------|----------------|----------|
|                                       |   | To (1)                                 | Pu (3,5)  | Pl (7)         | Gl (9) | Total |                   |                |          |
| 521A-1-1                              | G1 (9)  |  |           | 1 <sup>e</sup> | 19     | 20    | -                 | -              | -        |
|                                       | G1 (9)  |  |           |                | 13     | 13    | -                 | -              | -        |
|                                       | -3  |  |           |                | 15     | 15    | -                 | -              | -        |
|                                       | -4  |  |           |                | 19     | 19    | -                 | -              | -        |
|                                       | -5  |  |           |                | 17     | 17    | -                 | -              | -        |
|                                       | -6  |  |           |                | 8      | 8     | -                 | -              | -        |
|                                       | -7  |  |           |                | 10     | 10    | -                 | -              | -        |
|                                       | -8  |  |           |                | 13     | 13    | -                 | -              | -        |
|                                       | -9  |  |           |                | 12     | 12    | -                 | -              | -        |
|                                       | -10   |  |           |                | 19     | 19    | -                 | -              | -        |
|                                       | -11   |  |           |                | 16     | 16    | -                 | -              | -        |
|                                       | -12   |  |           |                | 15     | 15    | -                 | -              | -        |
| 521B-1-1                              | To (1)  | 16                                     | 4 (0,4)   |                |        | 20    | 3:1               | .267           | .50      |
|                                       | Pu (3)  | 8                                      | 10 (10,0) |                |        | 18    | 5:6:4:1           | 8.193          | .02      |
|                                       | To (1)  | 13                                     | 3 (0,3)   |                |        | 16    | "                 | .333           | .95      |
|                                       | -4  | 3                                      | 10 (10,0) | 2              | 1      | 16    | "                 | 4.467          | .10      |
|                                       | -5  | 11                                     | 6 (6,0)   |                |        | 17    | 3:1               | .961           | .30      |
|                                       | -6  | 12                                     | 3 (3,0)   |                |        | 15    | 3:1               | 2.000          | .10      |
|                                       | -7  |  | 8 (7,1)   |                |        | 8     | -                 | -              | -        |
|                                       | -8  | 3                                      | 5 (5,0)   |                |        | 8     | 3:1               | 6.000          | .01      |
|                                       | -9  | 13                                     | 4 (1,3)   |                |        | 17    | 3:1               | .196           | .70      |
|                                       | -10   | 13                                     | 4 (2,2)   |                |        | 17    | 3:1               | .196           | .70      |
|                                       | -11   | 6                                      | 5 (5,0)   | 4              | 1      | 16    | 5:6:4:1           | .367           | .90      |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |           |        |        |       | Expected<br>Ratio | x <sup>2</sup> | p <sup>b</sup> |
|---------------------------------------|---|--|-----------|--------|--------|-------|-------------------|----------------|----------------|
|                                       |   | To (1)                                 | Pu (3,5)  | Pl (7) | Gl (9) | Total |                   |                |                |
| 499A-1-1                              | Pl (7)  |  | 9 (4,5)   | 16     | 6      | 31    | 1:2:1             | .613           | .70            |
|                                       | Pu (5)  | 11                                     | 15 (5,10) | 8      | 3      | 37    | 5:6:4:1           | .492           | .90            |
|                                       | To (1)  | 27                                     | 8 (8,0)   |        |        | 35    | 3:1               | .857           | .30            |
|                                       | To (1)  | 30                                     | 8 (8,0)   |        |        | 38    | 3:1               | .316           | .50            |
|                                       | Pu (5)  | 34                                     | 3 (3,0)   |        |        | 38    | 5:6:4:1           | 60.400         | d              |
|                                       | Pu (5)  | 12                                     | 12 (10,2) | 3      | 2      | 29    | "                 | 3.580          | .30            |
|                                       | To (1)  | 35                                     |           |        |        | 35    | -                 | -              | -              |
|                                       | To (1)  | 33                                     |           |        |        | 33    | -                 | -              | -              |
|                                       | To (1)  | 33                                     |           |        |        | 33    | -                 | -              | -              |
|                                       | To (1)  | 20                                     | 5 (0,5)   |        |        | 25    | 3:1               | .333           | .50            |
|                                       | Pu (5)  | 11                                     | 11 (11,0) | 7      | 2      | 31    | 5:6:4:1           | .286           | .95            |
|                                       | To (1)  | 27                                     | 8 (4,4)   |        |        | 35    | 3:1               | .857           | .30            |
| 499A-3-1                              | Gl (9)  |  |           |        | 40     | 40    | -                 | -              | -              |
|                                       | Pu (3)  | 16                                     | 14 (14,0) | 5      | .1     | 36    | 5:6:4:1           | 4.496          | .20            |
|                                       | Pu (3)  | 12                                     | 12 (6,6)  | 8      | 3      | 35    | "                 | .565           | .90            |
|                                       | Pl (7)  |  | 13 (13,0) | 15     | 9      | 37    | 1:2:1             | 2.189          | .30            |
|                                       | To (1)  | 41                                     |           |        |        | 41    | -                 | -              | -              |
|                                       | Pl (7)  |  | 9 (9,0)   | 11     | 10     | 30    | 1:2:1             | 2.200          | .30            |
|                                       | To (1)  | 31                                     | 8 (6,2)   |        |        | 39    | 3:1               | .419           | .50            |
|                                       | Pu (3)  | 14                                     | 8 (3,5)   | 8      | 2      | 32    | 5:6:4:1           | 2.933          | .30            |
|                                       | Pu (3)  |  | 38 (35,3) |        |        | 38    | -                 | -              | -              |
|                                       | Pu (5)  | 25                                     | 6 (6,0)   |        |        | 31    | 5:6:4:1           | 36.613         | d              |
|                                       | Pu (3)  | 16                                     | 17 (12,5) | 6      | 3      | 42    | "                 | 2.711          | .30            |
|                                       | Pu (5)  | 10                                     | 15 (2,13) | 8      | 4      | 37    | "                 | 1.703          | .50            |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>FamilyC | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |                      |        |        |       | Expected<br>Ratio | x <sup>2</sup> | b <sup>b</sup><br>p> |
|---------------------------|---|--|----------------------|--------|--------|-------|-------------------|----------------|----------------------|
|                           |   | To (1)                                 | Pu (3,5)             | Pl (7) | Gl (9) | Total |                   |                |                      |
| 499B-3-1                  | Pu (3)  | 10                                     | 15 (5,10)            | 8      | 1      | 34    | 5:6:4:1           | 1.059          | .70                  |
|                           | To (1)  | 38                                     |                      |        |        | 38    | -                 | -              | -                    |
|                           | To (1)  | 28                                     | 8 (4,4)              |        |        | 36    | 3:1               | 1.481          | .20                  |
|                           | Pl (7)  |  | 8 (2,6)              | 18     | 9      | 35    | 1:2:1             | .857           | .50                  |
|                           | Pu (3)  | 10                                     | 14 (2,12)            | 8      | 2      | 34    | 5:6:4:1           | .196           | .95                  |
|                           | Pu (3)  | 6                                      | 15 (12,3)            | 6      | 3      | 30    | "                 | 3.440          | .30                  |
|                           | Pu (3)  | 16                                     | 9 (7,2)              | 7      | 1      | 30    | "                 | 4.794          | .10                  |
|                           | Pu (3)  | 13                                     | 14 (13,1)            | 10     | 1      | 38    | "                 | .933           | .80                  |
|                           | Pu (5)  | 19                                     | 9 (4,5)              |        |        | 28    | "                 | 20.971         | d                    |
|                           | To (1)  | 37                                     |                      |        |        | 37    | -                 | -              | -                    |
|                           | To (1)  | 34                                     | 1 <sup>e</sup> (1,0) |        |        | 35    | -                 | -              | -                    |
|                           | To (1)  | 33                                     |                      |        |        | 33    | -                 | -              | -                    |
| 499B-8-1                  | To (1)  | 41                                     |                      |        |        | 41    | -                 | -              | -                    |
|                           | Pu (3)  | 4                                      |                      |        |        | 4     | -                 | -              | -                    |
|                           | Pu (3)  | 7                                      | 8 (8,0)              | 11     | 3      | 26    | 5:6:4:1           | 6.687          | .05                  |
|                           | Pu (3)  | 9                                      | 14 (7,7)             | 12     | 5      | 38    | "                 | 5.565          | .10                  |
|                           | Pu (5)  | 9                                      | 15 (1,14)            | 12     | 3      | 36    | "                 | 1.492          | .50                  |
|                           | Pu (5)  |  | 30 (25,5)            |        |        | 30    | -                 | -              | -                    |
|                           | To (1)  | 40                                     |                      |        |        | 40    | -                 | -              | -                    |
|                           | Pu (3)  | 15                                     | 15 (6,9)             | 7      | 2      | 39    | 5:6:4:1           | 1.513          | .50                  |
|                           | To (1)  | 21                                     |                      |        |        | 21    | -                 | -              | -                    |
|                           | To (1)  | 41                                     |                      |        |        | 41    | -                 | -              | -                    |
|                           | To (1)  |  |                      |        |        |       | -                 | -              | -                    |
|                           | To (1)  |  |                      |        |        |       | -                 | -              | -                    |



TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |           |        |        |       | Expected<br>Ratio | X <sup>2</sup> | p <sup>b</sup> > |
|---------------------------------------|---|--|-----------|--------|--------|-------|-------------------|----------------|------------------|
|                                       |   | To (1)                                 | Pu (3,5)  | Pl (7) | Gl (9) | Total |                   |                |                  |
| 522A-2-1                              | To (1)  | 11                                     | 4 (3,1)   |        |        | 15    | 3:1               | .222           | .50              |
|                                       | Pu (5)  |  | 20 (11,9) |        |        | 20    | -                 | -              | -                |
|                                       | To (1)  | 16                                     | 6 (5,1)   |        |        | 22    | 3:1               | .606           | .30              |
|                                       | Pu (5)  | 2                                      | 5 (4,1)   |        | 2      | 9     | 5:6:5             | 1.252          | .50              |
|                                       | Gl (9)  |  | 1e(1e,0)  |        | 19     | 20    | -                 | -              | -                |
|                                       | Pu (3)  | 7                                      | 8 (4,4)   |        | 4      | 19    | 5:6:5             | .929           | .50              |
|                                       | To (1)  | 15                                     | 3 (3,0)   |        |        | 18    | 3:1               | .667           | .30              |
|                                       | To (1)  | 17                                     | 3 (3,0)   |        |        | 20    | 3:1               | 1.067          | .20              |
|                                       | Pu (3)  | 8                                      | 9 (9,0)   |        | 3      | 20    | 5:6:5             | 2.480          | .30              |
|                                       | Pl (7)  |  | 6 (3,3)   |        | 14     | 20    | 1:3               | .267           | .50              |
|                                       | To (1)  | 16                                     | 5 (5,0)   |        |        | 21    | 3:1               | .016           | .80              |
|                                       | Gl (9)  |  | 6 (1,5)   |        | 13     | 19    | 1:3               | .439           | .30              |
| 522A-3-1                              | Pu (5)  | 4                                      | 12 (6,6)  |        | 5      | 21    | 5:6:5             | 3.533          | .10              |
|                                       | To (1)  | 15                                     |           |        |        | 15    | -                 | -              | -                |
|                                       | Pu (3)  |  | 14        |        |        | 14    | -                 | -              | -                |
|                                       | Pu (5)  | 7                                      | 8 (3,5)   |        | 2      | 17    | 5:6:5             | 3.016          | .20              |
|                                       | Pu (5)  | 2                                      | 5 (3,2)   |        |        | 7     | 5:6:5             | 4.352          | .10              |
|                                       | Pu (6)  | 13                                     | 5 (3,2)   |        | 2      | 20    | 5:6:5             | 11.013         | d                |
|                                       | Pu (5)  | 7                                      | 10 (7,3)  |        | 5      | 22    | 5:6:5             | .885           | .50              |
|                                       | Gl (9)  |  |           |        | 18     | 18    | -                 | -              | -                |
|                                       | Gl (9)  |  | 6 (6,0)   |        | 12     | 18    | 1:3               | .667           | .30              |
|                                       | Gl (9)  |  | 8 (4,4)   |        | 12     | 20    | 1:3               | 2.400          | .10              |
|                                       | Gl (9)  |  | 7 (7,0)   |        | 10     | 17    | 1:3               | 2.373          | .10              |
|                                       | Pu (5)  |  | 14 (14,0) |        |        | 14    | -                 | -              | -                |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |           |        |                |       | Expected<br>Ratio | x <sup>2</sup> | p <sup>b&gt;</sup> |
|---------------------------------------|---|--|-----------|--------|----------------|-------|-------------------|----------------|--------------------|
|                                       |   | To (1)                                 | Pu (3,5)  | Pl (7) | Gl (9)         | Total |                   |                |                    |
| 522B-3-1                              | To (1)  | 16                                     | 3 (3,0)   |        |                | 19    | 3:1               | .860           | .30                |
|                                       | To (1)  | 19                                     |           |        |                | 19    | -                 | -              | -                  |
|                                       | To (1)  | 16                                     | 3 (3,0)   |        |                | 19    | 3:1               | .860           | .30                |
|                                       | Gl (9)  |  | 3 (3,0)   |        |                | 15    | 1:3               | 2.000          | .10                |
|                                       | Pu (3)  | 3                                      | 7 (6,1)   |        | 12             | 14    | 5:6:5             | 1.048          | .20                |
|                                       | Pu (3)  | 2                                      | 4 (0,4)   |        | 5              | 11    | "                 | 1.315          | .50                |
|                                       | Pu (5)  |  | 18 (6,12) |        |                | 18    | -                 | -              | -                  |
|                                       | Pu (3)  | 5                                      | 5 (2,3)   |        | 10             | 20    | 5:6:5             | 3.333          | .10                |
|                                       | To (1)  | 9                                      | 9 (6,3)   |        |                | 18    | 3:1               | 6.000          | .01                |
|                                       | To (1)  | 16                                     | 4 (4,0)   |        |                | 20    | 3:1               | .267           | .50                |
|                                       | To (1)  | 21                                     |           |        |                | 21    | -                 | -              | -                  |
|                                       | Gl (9)  |  | 7 (0,7)   |        | 14             | 21    | 1:3               | .778           | .30                |
| 522B-4-1                              | Gl (9)  |  | 4 (0,4)   |        | 15             | 19    | 1:3               | .158           | .50                |
|                                       | Pu (5)  | 5                                      | 7 (3,4)   |        | 6              | 18    | 5:6:5             | .104           | .90                |
|                                       | To (1)  | 19                                     | 1e(1e,0)  |        |                | 20    | -                 | -              | -                  |
|                                       | Gl (9)  |  |           |        | 18             | 18    | -                 | -              | -                  |
|                                       | Pu (3)  | 8                                      | 8 (4,4)   |        | 4              | 20    | 5:6:5             | 1.333          | .50                |
|                                       | Pu (3)  | 6                                      | 9 (8,1)   |        | 5              | 20    | "                 | .560           | .70                |
|                                       | Gl (9)  |  | 7 (1,6)   |        | 13             | 20    | 1:3               | 1.067          | .30                |
|                                       | Pu (5)  |  | 19 (1,18) |        | 1 <sup>e</sup> | 20    | -                 | -              | -                  |
|                                       | Pu (3)  | 5                                      | 8 (0,8)   |        | 6              | 19    | 5:6:5             | .256           | .80                |
|                                       | Pu (3)  | 4                                      | 9 (0,9)   |        | 7              | 20    | "                 | 1.200          | .50                |
|                                       | To (1)  | 16                                     | 5 (0,5)   |        |                | 21    | 3:1               | .159           | .50                |
|                                       | Pu (5)  |  | 17 (2,15) |        |                | 17    | -                 | -              | -                  |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |          |        |        |       | Expected<br>Ratio | X <sup>2</sup> | p <sup>b</sup> > |
|---------------------------------------|---|--|----------|--------|--------|-------|-------------------|----------------|------------------|
|                                       |   | To (1)                                 | Pu (3,5) | Pl (7) | Gl (9) | Total |                   |                |                  |
| 523-1-7                               | To (1)  | 18                                     | 3 (3,0)  |        |        | 21    | 3:1               | 1.286          | .20              |
|                                       | Pu (3)  | 7                                      | 6 (6,0)  |        |        | 18    | 5:6:5             | .489           | .70              |
|                                       | Pu (3)  | 5                                      | 7 (4,3)  |        | 5      | 19    | "                 | .340           | .80              |
|                                       | Pu (3)  | 7                                      | 8 (2,6)  |        | 6      | 21    | "                 | .794           | .50              |
|                                       | Pu (3)  | 7                                      | 2 (2,0)  |        | 9      | 18    | "                 | .570           | .70              |
| 523-2-2                               | Gl (9)  |  | 3 (0,3)  |        | 11     | 14    | 1:3               | .952           | .30              |
|                                       | Pu (3)  | 8                                      | 8 (8,0)  |        | 3      | 19    | 5:6:5             | 2.277          | .30              |
|                                       | Pu (3)  | 4                                      | 9 (7,2)  |        | 6      | 19    | "                 | 1.126          | .50              |
|                                       | To (1)  | 16                                     | 1 (1,0)  |        |        | 17    | 3:1               | 3.314          | .05              |
|                                       | Gl (9)  |  | 4 (0,4)  |        | 15     | 19    | 1:3               | .158           | .50              |
|                                       | To (1)  | 21                                     |          |        |        | 21    | -                 | -              | -                |
|                                       | To (1)  | 19                                     |          |        |        | 19    | -                 | -              | -                |
|                                       | To (1)  | 19                                     |          |        |        | 19    | -                 | -              | -                |
|                                       | To (1)  | 11                                     | 2 (2,0)  |        |        | 13    | 3:1               | .641           | .30              |
|                                       | Pu (5)  | 6                                      | 6 (4,2)  |        | 4      | 16    | 5:6:5             | .400           | .80              |
|                                       | Pu (5)  | 15                                     | 4 (4,0)  |        | 1      | 20    | "                 | 18.293         | d                |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |          |        |        |       | Expected<br>Ratio | x <sup>2</sup> | p <sup>b</sup> > |
|---------------------------------------|---|--|----------|--------|--------|-------|-------------------|----------------|------------------|
|                                       |   | To (1)                                 | Pu (3,5) | Pl (7) | Gl (9) | Total |                   |                |                  |
| 524-1-1                               | To (1)  | 14                                     | 3 (3,0)  |        |        | 17    | 3:1               | .490           | .30              |
|                                       | Pu (3)  | 6                                      | 7 (7,0)  |        |        | 20    | 5:6:5             | .133           | .90              |
|                                       | Pu (3)  | 6                                      | 8 (8,0)  |        | 7      | 20    | "                 | .533           | .70              |
|                                       | To (1)  | 12                                     | 3 (3,0)  |        | 6      | 15    | 3:1               | .200           | .50              |
|                                       | Pu (3)  | 6                                      | 8 (8,0)  |        | 5      | 19    | 5:6:5             | .256           | .80              |
|                                       | Gl (9)  |  | 7 (2,5)  |        | 11     | 18    | 1:3               | 1.852          | .10              |
|                                       | To (1)  | 21                                     |          |        |        | 21    | -                 | -              | -                |
|                                       | Pu (3)  | 4                                      | 9 (9,0)  |        | 4      | 17    | 5:6:5             | 1.729          | .30              |
| 524-2-1                               | To (1)  | 13                                     | 3 (3,0)  |        |        | 16    | 3:1               | .333           | .50              |
|                                       | To (1)  | 17                                     |          |        |        | 17    | -                 | -              | -                |
|                                       | Gl (9)  |  | 6 (0,6)  |        | 12     | 18    | 1:3               | .666           | .30              |
|                                       | Pu (3)  | 9                                      | 8 (2,6)  |        | 5      | 22    | 5:6:5             | 1.176          | .50              |
|                                       | Pu (3)  | 5                                      | 5 (1,4)  |        | 2      | 12    | "                 | 1.289          | .50              |
|                                       | Pu (3)  | 9                                      | 2 (2,0)  |        | 7      | 11    | 3:1               | .273           | .50              |
|                                       | Pu (5)  | 5                                      | 9 (1,8)  |        | 21     | 21    | 5:6:5             | .562           | .70              |
|                                       | Pu (5)  | 8                                      | 9 (9,0)  |        | 4      | 21    | "                 | 1.476          | .30              |
| 524-2-2                               | Pu (5)  | 3                                      | 8 (4,4)  |        | 5      | 16    | 5:6:5             | 1.467          | .30              |
|                                       | To (1)  | 8                                      |          |        |        | 8     | -                 | -              | -                |
|                                       | Pu (3)  | 7                                      | 5 (3,2)  |        | 8      | 20    | 5:6:5             | 1.413          | .30              |
|                                       | To (1)  | 12                                     | 8 (7,1)  |        |        | 20    | 3:1               | 2.400          | .10              |
|                                       | Pu (3)  | 5                                      | 5 (2,3)  |        | 5      | 15    | 5:6:5             | .111           | .90              |
|                                       | Pu (3)  |  |          |        |        |       |                   |                |                  |
|                                       | Pu (3)  |  |          |        |        |       |                   |                |                  |
|                                       | Pu (3)  |  |          |        |        |       |                   |                |                  |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |                      |        |                |       | Expected<br>Ratio | X <sup>2</sup> | p <sup>b</sup> > |
|---------------------------------------|---|--|----------------------|--------|----------------|-------|-------------------|----------------|------------------|
|                                       |   | To (1)                                 | Pu (3,5)             | Pi (7) | Gl (9)         | Total |                   |                |                  |
| 524-5-1                               | Gl (9)  |  | 3 (3,0)              |        | 12             | 15    | 1:3               | .200           | .50              |
| -2                                    | Pu (5)  | 6                                      | 8 (8,0)              |        | 4              | 19    | 5:6:5             | .726           | .50              |
| -3                                    | Pu (5)  | 7                                      | 9 (9,0)              |        | 2              | 18    | "                 | 3.422          | .10              |
| -4                                    | Gl (9)  |  | 6 (3,3)              |        | 15             | 21    | 1:3               | .143           | .70              |
| -5                                    | Pu (3)  |  | 18 (12,6)            |        |                | 18    | -                 | -              | -                |
| -6                                    | To (1)  | 14                                     | 4 (4,0)              |        |                | 18    | 3:1               | .741           | .30              |
| -7                                    | Pu (3)  | 6                                      | 7 (3,4)              |        | 4              | 17    | 5:6:5             | .475           | .70              |
| -8                                    | Pu (3)  | 7                                      | 7 (2,5)              |        | 4              | 18    | 5:6:5             | .815           | .50              |
| -9                                    | To (1)  | 14                                     | 5 (5,0)              |        |                | 19    | 3:1               | .175           | .50              |
| -10                                   | Gl (9)  |  |                      |        | 19             | 19    | -                 | -              | -                |
| -11                                   | Gl (9)  |  |                      |        | 1              | 1     | -                 | -              | -                |
| 524-7-2                               | Pu (5)  |  | 21 (1,20)            |        | 1 <sup>e</sup> | 22    | -                 | -              | -                |
| -3                                    | Pu (3)  |  | 26 (10,16)           |        |                | 26    | -                 | -              | -                |
| -4                                    | Gl (9)  |  | 9 (0,9)              |        | 31             | 40    | 1:3               | .133           | .70              |
| -5                                    | Pu (3)  |  | 42 (41,1)            |        |                | 42    | -                 | -              | -                |
| -6                                    | To (1)  | 27                                     | 12 (5,7)             |        |                | 39    | 3:1               | .692           | .30              |
| -7                                    | Gl (9)  |  | 13 (10,3)            |        | 25             | 38    | 1:3               | 1.720          | .10              |
| -8                                    | To (1)  | 38                                     | 1 <sup>e</sup> (1,0) |        |                | 39    | -                 | -              | -                |
| -9                                    | Gl (9)  |  |                      |        | 38             | 38    | -                 | -              | -                |
| -10                                   | To (1)  | 29                                     | 12 (12,0)            |        |                | 41    | 3:1               | .398           | .50              |
| -11                                   | To (1)  | 42                                     |                      |        |                | 42    | -                 | -              | -                |
| -12                                   | Pu (3)  | 8                                      | 12 (5,7)             |        | 8              | 22    | 5:6:5             | .343           | .80              |

TABLE 8 (CONTINUED)

| F3<br>Family <sup>c</sup> | F2<br>phenotype <sup>a</sup><br>(Score) |          | No. F3 Plants <sup>a</sup> |        |       |                |    | Expected<br>Ratio | x <sup>2</sup> | b <sup>b</sup><br>p <sup>b</sup> |
|---------------------------|---|----------|----------------------------|--------|-------|----------------|----|-------------------|----------------|----------------------------------|
|                           | To (1)                                  | Pu (3,5) | Pl (7)                     | Gl (9) | Total |                |    |                   |                |                                  |
| 525-1-1                   | To (1)                                  | 31       |                            |        |       |                | 31 | -                 | -              | -                                |
| -2                        | To (1)                                  | 33       |                            |        |       |                | 33 | -                 | -              | -                                |
| -3                        | Pu (5)                                  | 10       | 16 (16,0)                  |        |       | 9              | 36 | 5:6:5             | 1.496          | .30                              |
| -4                        | To (1)                                  | 21       | 13 (13,0)                  |        |       |                | 34 | 3:1               | 3.176          | .05                              |
| -5                        | Pu (3)                                  | 9        | 19 (19,0)                  |        |       | 9              | 37 | 5:6:5             | 3.029          | .20                              |
| -6                        | Pu (3)                                  | 9        | 11 (11,0)                  |        |       | 11             | 31 | "                 | .260           | .80                              |
| -7                        | Gl (9)                                  | 3        | 3 (2,1)                    |        |       | 7              | 10 | 1:3               | .133           | .70                              |
| -8                        | Pu (3)                                  | 9        | 16 (5,11)                  |        |       | 8              | 33 | 5:6:5             | 1.747          | .30                              |
| -9                        | Pu (3)                                  | 1        | 20 (11,9)                  |        |       | 7              | 28 | "                 | 15.810         | d                                |
| -10                       | Gl (9)                                  | 7        | 9 (0,9)                    |        |       | 14             | 23 | 1:3               | 2.450          | .10                              |
| -11                       | Pu (5)                                  |          | 15 (0,15)                  |        |       | 8              | 30 | 5:6:5             | 2.053          | .30                              |
| -12                       | Gl (9)                                  |          |                            |        |       | 30             | 30 | -                 | -              | -                                |
| 525-2-1                   | Gl (9)                                  |          | 1 (0,1)                    |        |       |                | 1  | -                 | -              | -                                |
| -2                        | To (1)                                  | 10       | 5 (5,0)                    |        |       |                | 15 | 3:1               | .556           | .30                              |
| -5                        | Gl (9)                                  |          |                            |        |       | 13             | 13 | -                 | -              | -                                |
| -6                        | Pu (3)                                  |          | 16 (6,10)                  |        |       | 1 <sup>e</sup> | 18 | -                 | -              | -                                |
| -7                        | Pu (5)                                  |          | 21 (7,14)                  |        |       |                | 21 | -                 | -              | -                                |
| -8                        | To (1)                                  |          | 7 (7,0)                    |        |       |                | 20 | 3:1               | 1.067          | .30                              |
| -9                        | To (1)                                  |          | 3 (3,0)                    |        |       |                | 17 | "                 | .490           | .30                              |
| -10                       | Pu (3)                                  |          | 2 (2,0)                    |        |       |                | 3  | 3:1               | 2.778          | .05                              |
| -11                       | To (1)                                  |          | 2 (2,0)                    |        |       |                | 15 | 3:1               | 1.089          | .20                              |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |           |        |        |       | Expected<br>Ratio | x <sup>2</sup> | b<br>p > |
|---------------------------------------|---|--|-----------|--------|--------|-------|-------------------|----------------|----------|
|                                       |   | To (1)                                 | Pu (3,5)  | Pl (7) | Gi (9) | Total |                   |                |          |
| 525-3-2                               | To (1)  | 21                                     | 12 (11,1) |        |        | 33    | 3:1               | 2.273          | .10      |
| -3                                    | Pu (3)  | 13                                     | 15 (12,3) |        |        | 38    | 5:6:5             | .442           | .80      |
| -4                                    | To (1)  | 28                                     | 9 (0,9)   |        | 10     | 34    | 3:1               | .901           | .30      |
| -5                                    | To (1)  | 26                                     | 10 (9,1)  |        |        | 36    | 3:1               | .148           | .70      |
| -6                                    | Pu (3)  | 3                                      | 15 (10,5) |        | 8      | 26    | 5:6:5             | 6.062          | .02      |
| -7                                    | To (1)  | 28                                     | 12 (10,2) |        |        | 40    | 3:1               | .533           | .30      |
| -8                                    | To (1)  | 14                                     | 6 (5,1)   |        |        | 20    | 3:1               | .267           | .50      |
| -9                                    | Pu (3)  | 7                                      | 12 (5,7)  |        | 5      | 24    | 5:6:5             | 1.867          | .30      |
| -10                                   | Pu (5)  | 13                                     | 3 (3,0)   |        | 10     | 26    | "                 | 8.031          | .01      |
| -11                                   | Gi (9)  |  | 12 (2,10) |        | 24     | 36    | 1:3               | 1.333          | .20      |
| -12                                   | To (1)  | 26                                     | 1 (1,0)   |        |        | 27    | -                 | -              | -        |
| 525-4-1                               | To (1)  | 15                                     | 5 (5,0)   |        |        | 20    | 3:1               | 0.000          | .99      |
| -2                                    | Pu (3)  |  | 34 (28,6) |        |        | 34    | -                 | -              | -        |
| -3                                    | To (1)  | 15                                     | 10 (10,0) |        |        | 35    | 3:1               | 3.000          | .05      |
| -4                                    | Pu (3)  | 8                                      | 15 (15,0) |        | 11     | 34    | 5:6:5             | 1.059          | .50      |
| -5                                    | Pu (5)  | 8                                      | 9 (9,0)   |        |        | 26    | "                 | .154           | .90      |
| -6                                    | Gi (9)  |  | 6 (6,0)   |        |        | 32    | 1:3               | .667           | .30      |
| -7                                    | Pu (3)  | 9                                      | 16 (16,0) |        | 26     | 37    | 5:6:5             | .910           | .50      |
| -8                                    | Gi (9)  |  | 8 (1,7)   |        | 18     | 26    | 1:3               | .462           | .30      |
| -9                                    | Gi (9)  | 9                                      | 10 (9,1)  |        | 11     | 29    | 5:6:5             | .436           | .90      |
| -10                                   | Pu (5)  | 9                                      | 21 (16,5) |        | 7      | 37    | "                 | 6.027          | .10      |
| -11                                   | Gi (9)  | 12                                     | 16 (10,6) |        | 11     | 39    | "                 | .248           | .95      |



TABLE 8 (CONTINUED)

| F <sub>2</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |           |                |        |       |
|---------------------------------------|---|--|-----------|----------------|--------|-------|
|                                       |   | To (1)                                 | Pu (3,5)  | Pl (7)         | Gl (9) | Total |
| 500A-1-1                              | G1 (9)  |  |           |                | 12     | 12    |
|                                       | G1 (9)  | 1                                      | 8 (3,5)   |                | 19     | 28    |
|                                       | G1 (9)  | 1                                      | 8 (8,0)   | 2              | 12     | 23    |
|                                       | Pl (7)  | 6                                      | 5 (5,0)   |                | 7      | 18    |
|                                       | Pl (7)  | 13                                     | 12 (10,2) | 1 <sup>e</sup> | 4      | 30    |
|                                       | Pl (7)  | 7                                      | 14 (9,5)  |                | 2      | 23    |
|                                       | G1 (9)  | 2                                      | 2 (2,0)   |                | 6      | 10    |
|                                       | To (1)  | 4                                      | 2 (1,1)   |                |        | 6     |
|                                       | G1 (9)  | 1                                      | 3 (0,3)   | 2              | 4      | 10    |
|                                       | G1 (9)  |  | 5 (2,3)   |                | 25     | 30    |
|                                       | G1 (9)  | 4                                      | 9 (9,0)   |                | 36     | 36    |
|                                       | G1 (9)  | 1                                      | 9 (5,4)   |                | 21     | 34    |
| 500A-8-1                              | G1 (9)  | 3                                      | 15 (4,11) |                | 7      | 17    |
|                                       | Pu (3)  | 10                                     | 17 (17,0) |                | 13     | 31    |
|                                       | Pu (3)  | 19                                     | 10 (9,1)  |                | 2      | 27    |
|                                       | G1 (9)  |  | 4 (0,4)   |                | 11     | 31    |
|                                       | G1 (9)  |  | 5 (1,4)   |                | 8      | 15    |
|                                       | To (1)  | 21                                     | 9 (0,9)   |                |        | 13    |
|                                       | Pu (3)  | 7                                      | 14 (12,2) |                | 11     | 30    |
|                                       | G1 (9)  | 1                                      | 9 (7,2)   |                | 13     | 32    |
|                                       | Pu (3)  | 8                                      | 16 (4,12) |                | 3      | 23    |
|                                       |   |  |           |                |        | 27    |
|                                       |   |  |           |                |        |       |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |           |        |        |       |
|---------------------------------------|---|--|-----------|--------|--------|-------|
|                                       |   | To (1)                                 | Pu (3,5)  | Pl (7) | Gl (9) | Total |
| 500B-2-1                              | Pu (3)  | 4                                      | 12 (6,6)  |        |        | 16    |
|                                       | Pl (7)  |  | 1 (1,0)   |        | 2      | 3     |
|                                       | Pl (7)  |  | 8 (8,0)   |        | 11     | 19    |
|                                       | Pl (7)  |  | 28 (5,23) |        | 9      | 37    |
|                                       | Pl (7)  | 3                                      | 5 (0,5)   |        | 4      | 12    |
|                                       | Gl (9)  |  | 13 (6,7)  |        | 5      | 18    |
|                                       | Pu (3)  | 18                                     | 18 (18,0) |        | 1      | 37    |
|                                       | Gl (9)  | 1                                      | 8 (4,4)   | 5      | 8      | 22    |
|                                       | Gl (9)  | 4                                      | 11 (6,5)  | 1      | 8      | 24    |
|                                       | Gl (9)  |  | 4 (3,1)   |        | 8      | 12    |
|                                       | Pu (3)  | 18                                     | 1e(1e,0)  |        |        | 19    |
|                                       | Pu (3)  | 2                                      | 1 (0,1)   |        |        | 3     |
| 500B-3-3                              | Pu (5)  |  | 4 (4,0)   |        | 6      | 10    |
|                                       | Gl (9)  | 1                                      | 16 (7,9)  |        | 15     | 32    |
|                                       | Pl (7)  | 1                                      | 19 (19,0) |        | 3      | 23    |
|                                       | Gl (9)  |  |           |        | 28     | 28    |
|                                       | Pu (5)  | 4                                      | 24 (20,4) |        | 3      | 31    |
|                                       | Gl (9)  |  |           |        | 20     | 20    |
|                                       | Gl (9)  |  |           |        | 23     | 23    |
|                                       | Pu (3)  | 3                                      | 3 (0,3)   |        | 17     | 23    |
|                                       | To (1)  | 16                                     |           |        |        | 16    |
|                                       |   |  |           |        |        |       |
|                                       |   |  |           |        |        |       |

TABLE 8 (CONTINUED)

| F <sub>3</sub><br>Family <sup>c</sup> | F <sub>2</sub><br>Phenotype <sup>a</sup><br>(Score) | No. F <sub>3</sub> Plants <sup>a</sup> |            |        |        |       |  |
|---------------------------------------|---|--|------------|--------|--------|-------|--|
|                                       |   | To (1)                                 | Pu (3,5)   | P1 (7) | G1 (9) | Total |  |
| 526-2-1                               | To (1)  | 7                                      | 12 (9,3)   |        |        | 19    |  |
|                                       | G1 (9)  |  | 10 (3,7)   |        | 11     | 21    |  |
|                                       | P1 (7)  | 6                                      | 24 (12,12) | 5      |        | 35    |  |
|                                       | G1 (9)  |  | 15 (8,7)   |        | 17     | 32    |  |
|                                       | G1 (9)  |  | 7 (7,0)    |        | 18     | 25    |  |
|                                       | G1 (9)  |  | 10 (2,8)   | 2      | 7      | 19    |  |
|                                       | To (1)  | 14                                     |            |        |        | 14    |  |
| 526-3-2                               | P1 (7)  | 18                                     | 10 (10,0)  |        |        | 28    |  |
|                                       | P1 (7)  | 13                                     | 13 (6,7)   |        | 7      | 34    |  |
|                                       | P1 (7)  |  | 6 (3,3)    |        |        | 6     |  |
|                                       | P1 (7)  | 6                                      | 5 (4,1)    |        |        | 11    |  |
|                                       | P1 (7)  | 5                                      | 13 (9,4)   |        | 3      | 21    |  |
|                                       | P1 (7)  | 6                                      | 6 (4,2)    | 1      | 1      | 14    |  |
|                                       | P1 (7)  | 7                                      |            |        |        | 7     |  |
| 526-4-1                               | P1 (7)  | 4                                      | 10 (7,3)   | 1      | 9      | 24    |  |
|                                       | G1 (9)  |  | 3 (0,3)    | 1      | 2      | 6     |  |
|                                       | G1 (9)  |  | 6 (2,4)    |        |        | 6     |  |
|                                       | G1 (9)  | 11                                     | 5 (1,4)    |        | 1      | 17    |  |
|                                       | G1 (9)  |  |            |        | 2      | 2     |  |
|                                       | G1 (9)  |  |            |        | 4      | 4     |  |
|                                       | G1 (9)  |  |            |        |        |       |  |

<sup>a</sup>To = Tomentose, Pu = Pubescent, P1 = Puberulent, G1 = Glabrous.

<sup>b</sup>Probability of a greater  $\chi^2$  value.

<sup>c</sup>Some F<sub>3</sub> families discarded due to damage during harvest.

<sup>d</sup> $P < .01$ .

<sup>e</sup>Probably a mixed plant.

included all the plants except some genotypes listed on the top line in the genetic models (Tables 4 and 6). It is possible that the hairs produced in the group IV crosses were more deciduous than those in groups I, II and III. Comparisons between data obtained from freshly harvested materials and those from dried stored materials are discussed later.

#### F<sub>2</sub> Generations-Groups I, II and III Results for 1972

Results shown in Table 9 generally supported the genetic ratios that were proposed. Data in cross 550 deviated significantly from the expected ratio. This was probably due to (1) a change in the genetic make-up of the UFP-3 and/or 'Georgia 119-20' plants used as parents, or (2) the effect of a heavy rain prior to scoring this cross, or (3) chance deviation. Data obtained from planting remnant F<sub>2</sub> seed in cross 521A indicated that the only seed obtained during the crossing season of 1966 was likely the result of self-pollination as assumed earlier.

The remnant F<sub>2</sub> and parental seed were stored at 18° to 21° C since 1965, 1967 and 1969. In most cases the unshelled peanuts, shelled seed and empty shells from a given plant were stored in the same bag. The viability of the stored seed was poor especially in tomentose and pubescent plants. This limited the number of remnant seed available for planting. The low yield of the F<sub>1</sub> plants in the 1971 crosses was due to their being grown in small pots in the greenhouses during the winter and to the incomplete breaking of the F<sub>2</sub> seed dormancy in one planting.

TABLE 9

F<sub>2</sub> SEGREGATION IN CROSSES OF GROUPS I, II AND III  
1972

| Group<br>(Ratio)         | Cross            | No. F <sub>1</sub><br>Plants | No. F <sub>2</sub> Plants <sup>a</sup> |     |     |     |       | X <sup>2</sup> | P <sup>b</sup> |
|--------------------------|------------------|------------------------------|--|-----|-----|-----|-------|----------------|----------------|
|                          |                  |                              | To                                     | Pu  | Pl  | Gl  | Total |                |                |
| I<br>(5:6:4:1)           | 521A             | 1 <sup>c</sup>               |  |     |     | 25  | 25    | 375.000        | **             |
|                          | 521B             | 1                            | 9                                      | 8   | 7   | 2   | 26    | .533           | .90            |
|                          | 521              | 1                            | 9                                      | 8   | 7   | 2   | 26    | .533           | .90            |
|                          | 548A             | 20                           | 65                                     | 81  | 53  | 17  | 216   | 1.019          | .70            |
|                          | 548B             | 42                           | 120                                    | 163 | 85  | 26  | 394   | 3.580          | .30            |
|                          | 548              | 62                           | 185                                    | 244 | 138 | 43  | 610   | 3.185          | .30            |
| Group Total              |                  | 63                           | 194                                    | 252 | 145 | 45  | 636   | 2.804          | .30            |
| II<br>(5:6:4:1)          | 499A             | 2                            | 23                                     | 29  | 18  | 5   | 75    | .086           | .99            |
|                          | 499B             | 2                            | 20                                     | 29  | 16  | 4   | 69    | .604           | .80            |
|                          | 499              | 4                            | 43                                     | 58  | 34  | 9   | 144   | .496           | .90            |
|                          | 547A             | 21                           | 72                                     | 102 | 63  | 20  | 257   | 2.178          | .50            |
|                          | 547B             | 35                           | 114                                    | 146 | 95  | 19  | 374   | 1.149          | .70            |
|                          | 547              | 56                           | 186                                    | 248 | 158 | 39  | 631   | 1.187          | .70            |
| Group Total              |                  | 60                           | 229                                    | 306 | 192 | 48  | 775   | 1.551          | .70            |
| III<br>(5:6:5)           | 522A             | 3                            | 10                                     | 17  |     | 10  | 37    | 1.126          | .50            |
|                          | 522B             | 2                            | 18                                     | 28  |     | 20  | 66    | .780           | .50            |
|                          | 522              | 5                            | 28                                     | 45  |     | 30  | 103   | 1.746          | .30            |
|                          | 523              | 4                            | 55                                     | 54  |     | 34  | 143   | 4.938          | .05            |
|                          | 524              | 4                            | 30                                     | 46  |     | 31  | 107   | 1.391          | .30            |
|                          | 525              | 4                            | 38                                     | 54  |     | 39  | 131   | .786           | .50            |
|                          | 549A             | 62                           | 102                                    | 146 |     | 106 | 354   | 2.188          | .30            |
|                          | 549B             | 12                           | 48                                     | 60  |     | 46  | 154   | .182           | .90            |
|                          | 549              | 74                           | 150                                    | 206 |     | 152 | 508   | 2.030          | .30            |
|                          | 550A             | 20                           | 72                                     | 96  |     | 53  | 221   | 5.939          | .05            |
|                          | 550B             | 37                           | 110                                    | 166 |     | 108 | 384   | 5.394          | .05            |
|                          | 550 <sup>d</sup> | 57                           | 182                                    | 262 |     | 161 | 605   | 9.867          | **             |
| Group Total <sup>d</sup> |                  | 91                           | 245                                    | 323 |     | 227 | 795   | 3.973          | .20            |

<sup>a</sup>To = Tomentose, Pu = Pubescent, Pl = Puberulent, Gl = Glabrous.<sup>b</sup>Probability of a greater X<sup>2</sup> value.<sup>c</sup>From a selfed seed, excluded from total.<sup>d</sup>Cross 550 had significantly large X<sup>2</sup> value, was excluded from total.

\*\*Significant at 1% level.

F<sub>2</sub> Generations-Group IV Results for 1972

As mentioned earlier, no genetic ratios were proposed after the first F<sub>2</sub> and F<sub>3</sub> plantings. In the 1972 planting, data on pod pubescence were collected on freshly dug peanuts (Table 10). Comparisons between these data and those obtained earlier on dried stored materials (Table 7) suggested that the pubescent class in these crosses had highly deciduous hairs as assumed earlier in these studies. The pod hairs apparently fell off as the fruit dried. The pods consequently appeared clean due to the removal of the soil particles previously attached. This was in line with the earliness in maturity of the UFG-4 and its offspring. It is also possible that the expression of the pubescence genes in the heterozygous condition was not stable in crosses involving the Virginia and Valencia genomes. The heterogeneous F<sub>3</sub> data (Table 8) for these crosses supported this assumption.

TABLE 10

F<sub>2</sub> SEGREGATION IN CROSSES OF GROUP IV  
1972

| Cross | No. F <sub>1</sub> | No. F <sub>2</sub> Plants |           |            |          | Total |
|-------|--------------------|---------------------------|-----------|------------|----------|-------|
|       | Plants             | Tomentose                 | Pubescent | Puberulent | Glabrous |       |
| 500A  | 2                  | 10                        | 7         | 13         | 32       | 62    |
| 500B  | 2                  | 6                         | 11        | 19         | 37       | 73    |
| 500   | 4                  | 16                        | 18        | 32         | 69       | 135   |
| 526   | 3                  | 9                         | 12        | 23         | 45       | 89    |
| Total | 7                  | 25                        | 30        | 55         | 114      | 224   |

Chlorophyll deficiencies present in the group IV crosses were ruled out as a factor affecting the pod pubescence segregation because of the low frequency of the albino plants. Only 6 albinos were observed among 224  $F_2$  plants.

The seed resulting from the group IV crosses were more variable in size than those from other crosses. A substantial proportion of the seed were very small (3 mm or less in diameter) even though they were apparently mature. In these crosses mature pods which appeared as singletons (small, ovoid and without constrictions) yet contained two or three seed\* were observed. Small pods with multiple constrictions produced many small seed. Samples of small and large  $F_2$  seed (separated by a 5.95 mm x 19.05 mm screen) were planted. The limited results indicated no associations between seed size and pod pubescence (Table 11).

#### $F_2$ Generations-Group V Results

The 1972 pod pubescence and seed coat color results are shown in Table 12. They fit to a ratio of 1:2:1 of tomentose to pubescent to glabrous plants, although the data in cross 551B deviated from this ratio at the 5% level (not at the 1% level). It is possible that (1) a gene different from  $Pu_1$ ,  $Pu_2$  and  $Pu_3$  was responsible for the pod pubescence in these crosses, or (2)  $Pu_1$ ,  $Pu_2$  or  $Pu_3$  was acting in a different background having different modifiers; or (3) the deviation

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\*This indicates independence of pod size and number of seed in fruit development in the presence of Virginia and Valencia genomes.



was due to chance alone.

The data fit a ratio of 15:1 of flesh-seeded to white-seeded plants ( $\chi^2 = 2.541$ ;  $P > .10$ ) indicating duplicate dominant epistasis.

TABLE 11

SIMILARITY IN  $F_2$  SEGREGATION IN  
PLANTS GROWN FROM LARGE AND SMALL SEED<sup>a</sup>  
1972

| Sample <sup>c</sup> | Number of $F_2$ Plants <sup>b</sup> |            |            |            |       |
|---------------------|-------------------------------------|------------|------------|------------|-------|
|                     | Tomentose                           | Pubescent  | Puberulent | Glabrous   | Total |
| Large Seed          | 10 (8.83)                           | 17 (15.45) | 18 (17.66) | 35 (38.07) | 80    |
| Small Seed          | 6 (7.17)                            | 11 (12.55) | 14 (14.34) | 34 (30.93) | 65    |
| Total               | 16                                  | 28         | 32         | 69         | 145   |

<sup>a</sup>Large and small seed separated by a 5.95 mm x 19.05 mm screen.

<sup>b</sup>Expected number in parentheses following the observed number.

<sup>c</sup>Homogeneity  $\chi^2 = 1.261$ ; Probability of a greater  $\chi^2$  value  $> .70$ .

TABLE 12

F<sub>2</sub> SEGREGATION IN CROSSES OF GROUP V  
1972

| Cross | Plants | No. F <sub>2</sub> Plants <sup>a,b</sup> |          |         | Expected Ratio | Pod Pubescence |                | Seed Coat Color |                |
|-------|--------|--|----------|---------|----------------|----------------|----------------|-----------------|----------------|
|       |        | To                                       | Pu       | Gl      |                | X <sup>2</sup> | p <sup>c</sup> | X <sup>2</sup>  | p <sup>c</sup> |
| 551A  | 34     | 77 (3)                                   | 176 (11) | 88 (4)  | 341 (18)       | 1:2:1          | .50            | 1.444           | .30            |
| 551B  | 23     | 51 (1)                                   | 116 (4)  | 36 (1)  | 203 (6)        | "              | .02            | .667            | .70            |
| 551   | 57     | 128 (4)                                  | 292 (15) | 124 (5) | 544 (24)       | "              | .20            | 1.583           | .30            |

<sup>a</sup>To = Tomentose, Pu = Pubescent, Gl = Glabrous.

<sup>b</sup>Number of white-seeded plants in parentheses following the total number of plants in each pubescence class.

<sup>c</sup>Probability of a greater X<sup>2</sup> value.

Pod pubescence was not associated with seed coat color as indicated by  $\chi^2$  tests for independence (Table 13). These tests were conducted with the assumptions of (1) known genetic ratios for both characters, (2) known genetic ratio for pod pubescence and (3) no known genetic ratios. There was no evidence of linkage between the genes for pod pubescence and for seed coat color.

#### Relation of Pod Pubescence to Yield

The peanut lines in each plot of the yield test were examined at harvest for pod pubescence. In all four blocks the ratings were the same for each line. In some cases, a few (less than 5) plants of different ratings were found in the same plot. This was probably due to segregation of some  $F_3$  plants or to mechanical seed mixtures. The ratings corresponded exactly with the  $F_3$  ratings when the lines were selected for the yield test (Table 14).

The yield of unshelled peanuts (UP), shelled peanuts (SP) and sound mature seed (SMK) and the corresponding analyses of variance are presented in Tables 15, 16 and 17, respectively. In all three variables, the mean squares for blocks and for lines were significant at the 1% level. The mean square for gypsum levels was significant at the 5% level only for the yield of SMK. The mean squares for lines x gypsum levels interaction in all three variables were not significant.

The mean yields of UP, SP and SMK per plot and per hectare are shown in Table 18 with their corresponding least significant differences (LSD) at 5% and 1% levels. The

TABLE 13

TESTS OF INDEPENDENCE<sup>a</sup> FOR POD PUBESCENCE AND SEED COAT COLOR  
1972

| Seed Coat<br>Color | Pod Pubescence |           |          | Total |
|--------------------|----------------|-----------|----------|-------|
|                    | Tomentose      | Pubescent | Glabrous |       |
| Flesh              | 124            | 277       | 119      | 520   |
| White              | 4              | 15        | 5        | 24    |
| Total              | 128            | 292       | 124      | 544   |

<sup>a</sup>With assumptions that (1) the inheritance of both characters is known (1:2:1 and 15:1);  $X^2 = 6.619$ ;  $P > .20$  or, (2) only the inheritance of pod pubescence is known (1:2:1);  $X^2 = 1.583$ ;  $P > .30$  or, (3) the inheritance of both characters is not known;  $X^2 = .915$ ;  $P > .50$ .

TABLE 14

PHENOTYPES OF SIX PEANUT LINES IN YIELD TEST

| Line | Phenotype |
|------|-----------|
| L1   | Tomentose |
| L2   | Tomentose |
| L3   | Tomentose |
| L4   | Pubescent |
| L5   | Glabrous  |
| L6   | Glabrous  |

TABLE 15

## YIELD OF UNSHELLED PEANUTS AND ITS ANALYSIS OF VARIANCE

Six Pubescence Lines at Two Gypsum Levels in Four Blocks  
(Kg per Plot of 1.8 m x 6 m)

| Line:<br>L | Gypsum<br>Level: G | Block |       |       |       | Total  |
|------------|--------------------|-------|-------|-------|-------|--------|
|            |                    | 1     | 2     | 3     | 4     |        |
| 1          | 0                  | 3.714 | 3.714 | 3.600 | 4.309 | 15.337 |
|            | 1                  | 4.423 | 3.572 | 3.402 | 4.848 | 16.245 |
| 2          | 0                  | 3.033 | 2.778 | 3.147 | 3.827 | 12.785 |
|            | 1                  | 3.430 | 3.175 | 3.941 | 4.026 | 14.572 |
| 3          | 0                  | 2.070 | 1.758 | 2.551 | 3.005 | 9.384  |
|            | 1                  | 2.807 | 2.665 | 3.487 | 3.345 | 12.304 |
| 4          | 0                  | 4.423 | 3.827 | 4.111 | 4.309 | 16.670 |
|            | 1                  | 3.629 | 3.023 | 4.423 | 5.500 | 16.575 |
| 5          | 0                  | 3.402 | 3.289 | 2.892 | 3.402 | 12.985 |
|            | 1                  | 2.722 | 2.778 | 3.402 | 2.948 | 11.850 |
| 6          | 0                  | 3.827 | 2.466 | 2.750 | 2.693 | 11.736 |
|            | 1                  | 3.005 | 2.410 | 3.430 | 3.260 | 12.105 |

| Source of<br>Variation | Degree of<br>Freedom | Sum of<br>Squares | Mean<br>Square | F        |
|------------------------|----------------------|-------------------|----------------|----------|
| Blocks                 | 3                    | 4.209             | 1.403          | 8.252**  |
| Treatments             | 11                   | 14.617            | 1.329          | 7.537**  |
| Lines                  | 5                    | 12.869            | 2.574          | 15.141** |
| Gypsum                 | 1                    | .471              | .471           | 2.676    |
| Lines x Gypsum         | 5                    | 1.277             | .255           | 1.449    |
| Error                  | 33                   | 5.817             | .176           | --       |
| Total                  | 47                   | 24.642            | --             | --       |

\*\*Significant at 1% level.

TABLE 16

## YIELD OF SHELLED PEANUTS AND ITS ANALYSIS OF VARIANCE

Six Pubescence Lines at Two Gypsum Levels in Four Blocks  
(Kg per Plot of 1.8 m x 6 m)

| Line:<br>L | Gypsum<br>Level: G | Block |       |       |       | Total  |
|------------|--------------------|-------|-------|-------|-------|--------|
|            |                    | 1     | 2     | 3     | 4     |        |
| 1          | 0                  | 2.806 | 2.776 | 2.691 | 3.275 | 11.548 |
|            | 1                  | 3.417 | 2.742 | 2.517 | 3.672 | 12.348 |
| 2          | 0                  | 2.207 | 2.063 | 2.282 | 2.755 | 9.307  |
|            | 1                  | 2.504 | 2.326 | 2.857 | 2.929 | 10.616 |
| 3          | 0                  | 1.485 | 1.292 | 1.830 | 2.119 | 6.726  |
|            | 1                  | 2.007 | 1.972 | 2.546 | 2.408 | 8.933  |
| 4          | 0                  | 3.406 | 2.918 | 3.165 | 3.178 | 12.667 |
|            | 1                  | 2.767 | 2.328 | 3.395 | 4.153 | 12.643 |
| 5          | 0                  | 2.483 | 2.376 | 2.075 | 2.424 | 9.358  |
|            | 1                  | 2.000 | 2.000 | 2.483 | 2.167 | 8.650  |
| 6          | 0                  | 2.669 | 1.578 | 1.760 | 1.602 | 7.609  |
|            | 1                  | 2.164 | 1.633 | 2.418 | 2.225 | 8.440  |

| Source of Variation | Degree of Freedom | Sum of Squares | Mean Square | F        |
|---------------------|-------------------|----------------|-------------|----------|
| Blocks              | 3                 | 2.008          | .669        | 6.027**  |
| Treatments          | 11                | 11.250         | 1.023       | 9.216**  |
| Lines               | 5                 | 10.198         | 2.040       | 18.378** |
| Gypsum              | 1                 | .406           | .406        | 3.658    |
| Lines x Gypsum      | 5                 | .646           | .129        | 1.162    |
| Error               | 33                | 3.667          | .111        | --       |
| Total               | 47                | 16.924         | --          | --       |

\*\* Significant at 1% level.

TABLE 17

## YIELD OF SOUND MATURE SEED AND ITS ANALYSIS OF VARIANCE

Six Pubescence Lines at Two Gypsum Levels in Four Blocks  
(Kg per Plot of 1.8 m x 6 m)

| Line:<br>L | Gypsum<br>Level: G | Block |       |       |       | Total  |
|------------|--------------------|-------|-------|-------|-------|--------|
|            |                    | 1     | 2     | 3     | 4     |        |
| 1          | 0                  | 2.600 | 2.562 | 2.502 | 3.038 | 10.702 |
|            | 1                  | 3.293 | 2.572 | 2.373 | 3.454 | 11.694 |
| 2          | 0                  | 2.100 | 1.972 | 2.077 | 2.612 | 8.761  |
|            | 1                  | 2.341 | 2.230 | 2.690 | 2.687 | 9.948  |
| 3          | 0                  | 1.392 | 1.204 | 1.652 | 1.908 | 6.156  |
|            | 1                  | 1.895 | 1.852 | 2.441 | 2.208 | 8.396  |
| 4          | 0                  | 3.185 | 2.822 | 3.022 | 2.898 | 11.927 |
|            | 1                  | 2.649 | 2.245 | 3.306 | 4.029 | 12.229 |
| 5          | 0                  | 2.373 | 2.105 | 1.894 | 2.160 | 8.532  |
|            | 1                  | 1.899 | 1.827 | 2.330 | 2.019 | 8.075  |
| 6          | 0                  | 2.535 | 1.351 | 1.561 | 1.414 | 6.861  |
|            | 1                  | 2.119 | 1.494 | 2.375 | 2.095 | 8.083  |

| Source of Variation | Degree of Freedom | Sum of Squares | Mean Square | F        |
|---------------------|-------------------|----------------|-------------|----------|
| Blocks              | 3                 | 1.719          | .573        | 5.026**  |
| Treatments          | 11                | 11.026         | 1.002       | 8.772**  |
| Lines               | 5                 | 9.876          | 1.975       | 17.325** |
| Gypsum              | 1                 | .627           | .627        | 5.500*   |
| Lines x Gypsum      | 5                 | .523           | .105        | --       |
| Error               | 33                | 3.746          | .114        | --       |
| Total               | 47                | 16.491         | --          | --       |

\*Significant at 5% level.

\*\*Significant at 1% level.



TABLE 18

AVERAGE YIELD OF UNSHELLED PEANUTS, SHELLED PEANUTS  
AND SOUND MATURE SEED OF SIX PUBESCENCE LINES

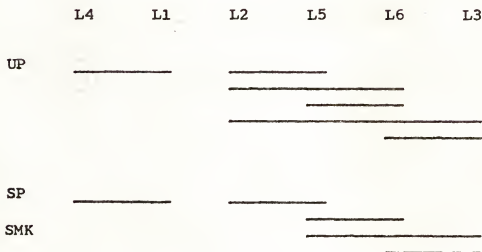
| Line:<br>L | Yield (Kg)            |             |                       |             |                       |             |
|------------|-----------------------|-------------|-----------------------|-------------|-----------------------|-------------|
|            | Unshelled Peanuts     |             | Shelled Peanuts       |             | Sound Mature Seed     |             |
|            | Per Plot <sup>a</sup> | Per Hectare | Per Plot <sup>b</sup> | Per Hectare | Per Plot <sup>c</sup> | Per Hectare |
| 1          | 3.948                 | 3541        | 2.987                 | 2679        | 2.799                 | 2511        |
| 2          | 3.420                 | 3067        | 2.490                 | 2234        | 2.339                 | 2098        |
| 3          | 2.711                 | 2432        | 1.957                 | 1756        | 1.819                 | 1632        |
| 4          | 4.156                 | 3728        | 3.164                 | 2838        | 3.019                 | 2708        |
| 5          | 3.104                 | 2785        | 2.251                 | 2019        | 2.076                 | 1862        |
| 6          | 2.980                 | 2673        | 2.006                 | 1799        | 1.868                 | 1676        |

<sup>a</sup>Least Significant Difference (LSD) = .427 (5% level) and .574 (1% level).

<sup>b</sup>LSD = .339 (5% level) and .455 (1% level).

<sup>c</sup>LSD = .343 (5% level) and .460 (1% level).

Duncan multiple range comparisons for the mean yields per plot in three variables are represented as follows:



In the above diagram the pubescence lines underscored by the same line are not significantly different in yield. According to these comparisons, lines L4 and L1 yielded better than the other lines. However the single degree of freedom comparisons of tomentose lines (L1, L2 and L3) and glabrous lines (L5 and L6) indicated that on the average the tomentose lines had a higher yield than the glabrous lines (Table 19).

TABLE 19

## COMPARISONS OF TOMENTOSE AND GLABROUS LINES OF PEANUTS

| Variable          | Mean Square<br>(d. f.) | Error Mean<br>Square (d. f.) | F        |
|-------------------|------------------------|------------------------------|----------|
| Unshelled Peanuts | .966 (1)               | .176 (33)                    | 5.480*   |
| Shelled Peanuts   | 1.174 (1)              | .111 (33)                    | 10.576** |
| Sound Mature Seed | 1.156 (1)              | .114 (33)                    | 10.145** |

\* Significant at 5% level.

\*\* Significant at 1% level.

## DISCUSSION

### Inheritance of Pod Pubescence

The results in different crosses involving the same glabrous parental line and different tomentose parental lines (Table 2, group I and group III) indicated that UFP-1, UFP-2 and UFP-3 were identical with respect to pod pubescence. This is likely because UFP-2 and UFP-3 were selected from the offspring of UFP-1 and its sister line and because of the relatively simple inheritance of pod pubescence.

No dominance of pod pubescence coverage that associated with pod dirtiness was observed in the crosses studied. Dominance could be considered incomplete, since the  $F_1$  pods were almost as pubescent as the tomentose parents. However if scoring was based on the presence or absence of hairs or dirtiness, in many cases pubescence would be considered as completely dominant. It is important to specify the aspect of pubescence being dealt with since pubescence is a complex character. The hairs could be present or absent, and when present, they could be long or short, dense or sparse, uniform or irregular in length or distribution. The results in these studies are in agreement with Saunders' report (64) on the complexity of pubescence in cotton. He found that hair length and distribution can vary independently of density. Ware (86) however found that hair coverage and hair length

were controlled by the same gene.

Bernard and Singh (9) found relatively discrete classes of pubescence when each type of pubescence was considered separately. However, in combination and if numerical scores were given to the degrees of pubescence, additive effects were obvious. Similarly, additive genes were found to control the inheritance of number of foliar glands in sesame (38) and glume hair length in wheat (74).

The different behavior of gene Pu<sub>2</sub> and Pu<sub>3</sub> for pod pubescence was similar to that of H<sub>1</sub> and H<sub>2</sub> or H<sub>1</sub><sup>P</sup> and H<sub>2</sub><sup>A</sup> in cottons (31-35, 44).

In soybeans, dominance relationships for plant pubescence have been shown to depend on the stage of the plant (9). The F<sub>1</sub> hybrids between the curly pubescent type and the normal pubescent type had normal appearing pubescence in the seedling stage, an intermediate semi-curly appearance in later stage, and at maturity required close inspection to be distinguished from the curly type. Thus from the same cross, a gene could be judged as dominant, incompletely dominant or recessive depending upon the stage of development. Therefore in inheritance studies it is important that the parental lines be planted next to the segregating populations for comparison.

Dominance for a characteristic cannot be determined from the study of one or two crosses. From the models in Tables 4 and 6 it could be seen that if a cross was made between a tomentose plant Pu<sub>1</sub>Pu<sub>1</sub>Pu<sub>2</sub>Pu<sub>2</sub> and a pubescent plant Pu<sub>1</sub>Pu<sub>1</sub>pu<sub>2</sub>pu<sub>2</sub>, hairiness would appear to be completely dominant. On the

other hand, if a cross was made between a pubescent plant Pu<sub>1</sub>Pu<sub>1</sub>pu<sub>2</sub>pu<sub>2</sub> and a glabrous plant pu<sub>1</sub>pu<sub>1</sub>pu<sub>2</sub>pu<sub>2</sub>, intermediate inheritance would be inferred. In a third instance, if a pubescent plant pu<sub>1</sub>pu<sub>1</sub>Pu<sub>2</sub>Pu<sub>2</sub> was crossed with a glabrous plant pu<sub>1</sub>pu<sub>1</sub>pu<sub>2</sub>pu<sub>2</sub> glabrousness would appear to be dominant to pubescence. This could be one of the reasons for the seemingly conflicting reports on dominance of plant pubescence in cotton (1, 4, 23, 40).

In the present studies two loci were involved in each cross, except in cross 551 (Group V) only one gene was acting, and in group IV crosses the mode of inheritance was not known. Since more genes appeared to be involved when more crosses were studied, the total number of genes controlling pod pubescence in the cultivated peanut may be large. Only from crosses between peanut lines of various sources supplying pubescence genes can reliable information on the number of genes be obtained. The cultivar Georgia 119-20 appears to be different from other glabrous parental lines in two or three pubescence genes. Different ways of F<sub>2</sub> classification may reveal different modes of inheritance. However knowledge on the inheritance of pod pubescence as it appears to the naked eye would help peanut breeders in making selection by visual observation. In instances where intensive studies have been conducted in other species, several genes for pubescence have been found (7, 9, 14, 26, 31-35, 63, 90).

#### Implications in Peanut Breeding

The inheritance of pod pubescence in most of the crosses

studied appears to be simple enough to allow effective selection in the  $F_2$  and  $F_3$ . In crosses of groups I and II (Table 4) selection for a true-breeding glabrous type can be achieved in the  $F_2$ . Unless other scoring techniques are found, the selection for the pubescent and the tomentose types in these crosses and other types in group III crosses must be deferred until the  $F_3$  generation. The knowledge of the inheritance of pod pubescence however would help reduce the number of  $F_2$  seed that must be planted to progeny-test for selection. The effectiveness of selection based on the above information was demonstrated by the successful selection of the four  $F_3$  families for the yield test in these studies. The lines selected were apparently homozygous for the level of pod pubescence expected (Table 14).

#### Relation of Pod Pubescence to Yield

The Duncan multiple range comparisons indicated that a tomentose line (L1) and a pubescent line (L4) yielded significantly higher than two other tomentose lines (L2 and L3) and the two glabrous lines (L5 and L6). Yield of a line seemed to be affected by some other genetic factors. However, the comparisons of yield in all the tomentose lines and all the glabrous lines (Table 19) indicated that the tomentose lines yielded more peanuts than the glabrous lines. The increased yield may be due to increased absorption of water and nutrients through the pods or to linkage of the pubescence genes and the genes for high yield. Plant vigor and high yield have

been found to be associated in soybean (45, 50, 69, 75, 84, 92) cotton (1) and tomato (60). Only in the tomato did the relationship appear to be well understood (60). It is unlikely that the increased yield was due to the differential insect resistance in the tomentose lines as in the cases reviewed by Painter (51). The pod hair seemed to have a stronger effect on the yield of seed than on the yield of unshelled peanuts (Table 19). This was due to better pod filling and less seed damage in the tomentose lines. The effect of pod hairs in the peanut, if any, contributes to the high yield only to a limited extent.

The effect of gypsum in this experiment was significant at the 5% level for the yield of SMK but not for the yield of UP and SP. This was probably due to better pod filling and reduced seed damage in the tomentose lines as indicated by the difference in the yields of UP, SP and SMK (Tables 15, 16 and 17). Before gypsum was applied the calcium level in the experimental field was 737 kg/ha of Ca in the top 15 cm of soil. At this level commercial varieties of peanuts normally do not respond significantly to calcium application.\* The lines x gypsum interaction was not significant. The peanut lines chosen responded similarly to gypsum. It was possible that the effect of gypsum was slight (Tables 15, 16 and 17) making differential response undetected. It was

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\*See Bracho, E. A. "Effect of soil pH and calcium sources on the yield grade and mineral composition of Virginia botanical type peanuts." Unpublished Master's Thesis, University of Florida. 1971.



also possible that calcium was not significantly absorbed through the pod via the pod hairs but via the epidermal cells when the pods were immature. More precise studies are needed, probably using radioactive calcium, to understand how calcium is taken up by the peanut pod and peg. Pod hairs possibly affect absorption of water and elements other than calcium, since they have been shown to be absorbed through the pod and the peg (23).

## SUMMARY AND CONCLUSIONS

Crosses involving peanut cultivars and breeding lines were analyzed to study the inheritance of pod pubescence. Six lines apparently homozygous for different degrees of pubescence were compared in a yield test to detect the association between pod pubescence and yielding ability. The following conclusions appeared to be justified from these studies:

1. The genes for pod pubescence were without dominance.
2. No differences were found between the reciprocal crosses with respect to pod pubescence.

3. In three of the five groups of crosses two gene pairs segregating independently and acting additively were involved. In two crosses only one gene pair was involved. In three other crosses the inheritance of pod pubescence was unknown probably due to the effect of other factors. Modifier genes may have also been involved. At least three or perhaps four loci were shown to control pod pubescence in the cultivated peanut.

4. One gene for pod pubescence was shown not to be linked to the genes for seed coat color in UFP-4.

5. The relatively simple mode of inheritance in certain crosses allowed effective selection for the desired pubescence levels. The effective selection was demonstrated by the total success in the selection of the pubescence lines

for the study of the relation of pod pubescence and yield of peanut at populational level.

6. On the average the tomentose lines had a higher yield of unshelled peanuts, shelled peanuts and sound mature seed than the glabrous lines. However, yield in peanuts depended mainly on factors other than pod pubescence. More lines need to be tested before a more definite relationship can be established.

7. Gypsum affected similarly the yield of peanuts in lines differing in pod pubescence.

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## BIOGRAPHICAL SKETCH

Nguyễn Van Tân was born August 1, 1939 in Hanam, Vietnam. Upon graduation from Chu Van An High School in Saigon in 1959, he was selected to study at the School of Public Works. He was also selected to study at the National College of Agriculture at Bao-loc where he completed his freshman year. From 1960 he attended the University of Florida and obtained the degree of Bachelor of Science in Agriculture with honors in 1962 and the degree of Master of Science in Agriculture in 1964. From 1964 to 1967 he was a member of the staff of the National Agricultural Center in Saigon.

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Nguyễn Van Tân is married to the former Lê Oanh Ngũ and is the father of a boy. He is a member of Alpha Zeta honorary fraternity and Phi Kappa Phi honor society. He is also a member of the American Peanut Research and Education Association and the American Society of Agronomy.

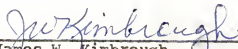
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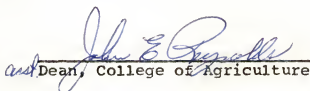


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December, 1972

  
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